

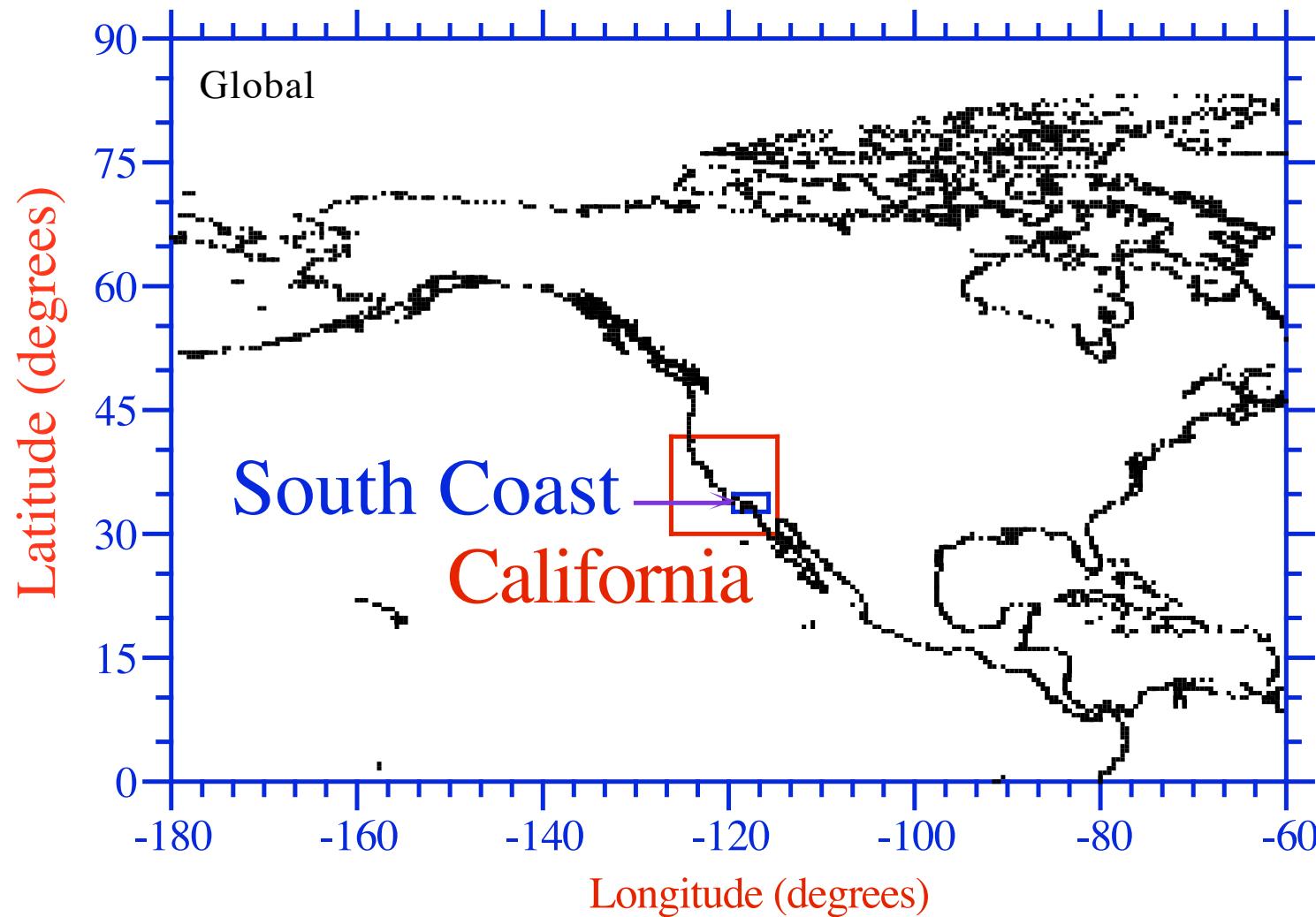
# **Role of Aerosols in Regional Climate: A Research Frontier**

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University

2<sup>nd</sup> Annual Climate Change Research Conference  
1<sup>st</sup> Scientific Conf., West Coast Governor's Global Warming Initiative  
California Energy Commission  
Sept. 14-16, 2005

# Model Grids Treated for California Case



# GATOR-GCMOM

## Gas processes

Emission  
Photochemistry  
Gas-to-particle conversion  
Cloud removal

## Aerosol processes

Emission  
Nucleation/condensation  
Gas dissolution  
Aqueous chemistry  
Crystallization  
Aerosol-aerosol coagulation  
Aerosol-cloud coagulation

Dry deposition

Sedimentation

Rainout/washout

## Meteorological processes

Pressure, winds, temp., TKE

## Cloud processes

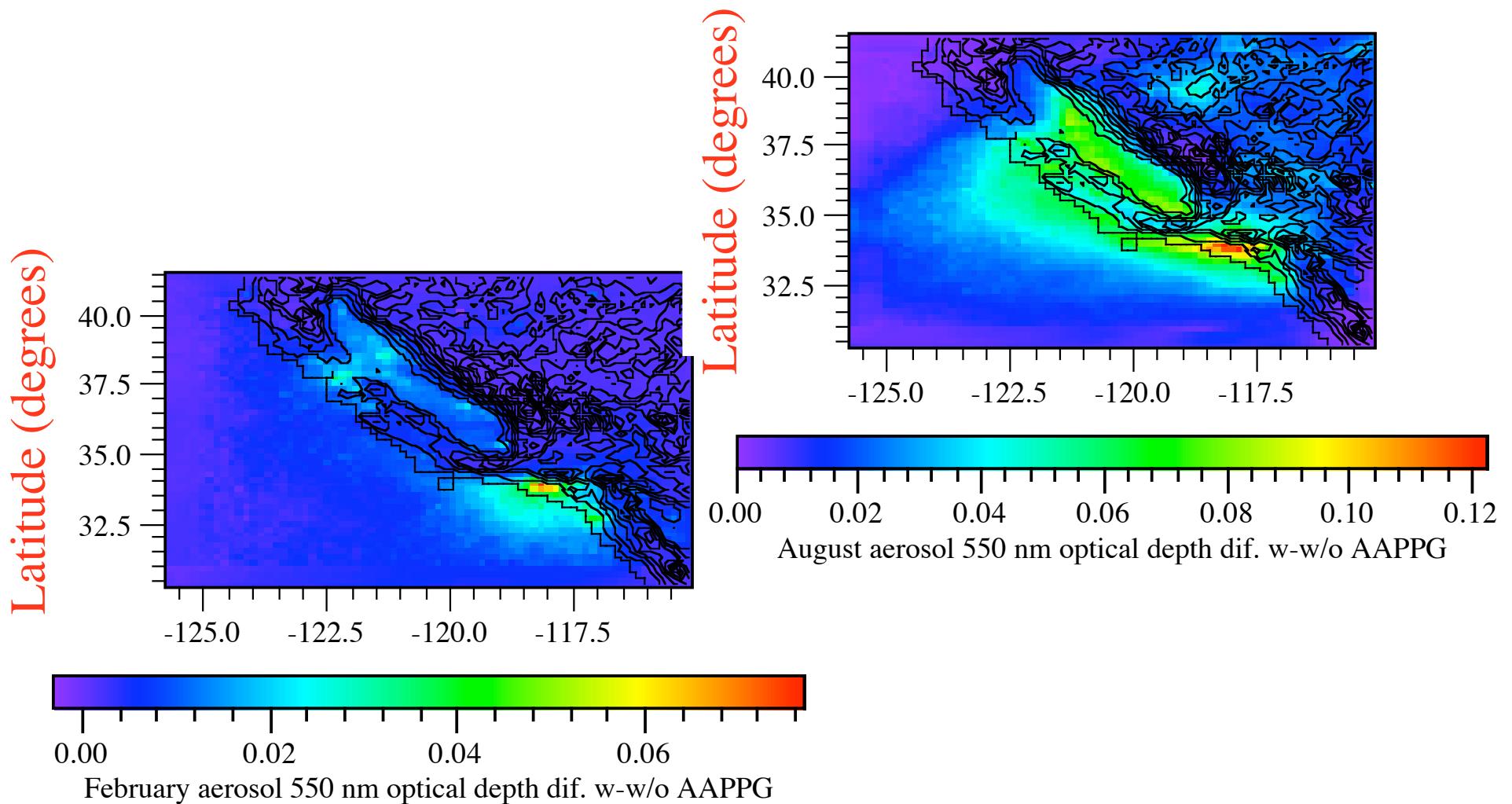
Time-dependent 3-D size-res. clouds  
Liquid/ice growth on aerosol particles  
Liquid drop freezing/breakup  
Hydrometeor-hydrometeor coagulation  
Hydrometeor-aerosol coagulation  
Precipitation, aer./gas rainout/washout  
Below-cloud evaporation/melting  
Lightning from collision bounceoffs  
Radiative transfer

UV/visible/near-IR/thermal-IR  
Gas/aerosol/cloud scat./absorption  
Predicted snow, ice, water albedos

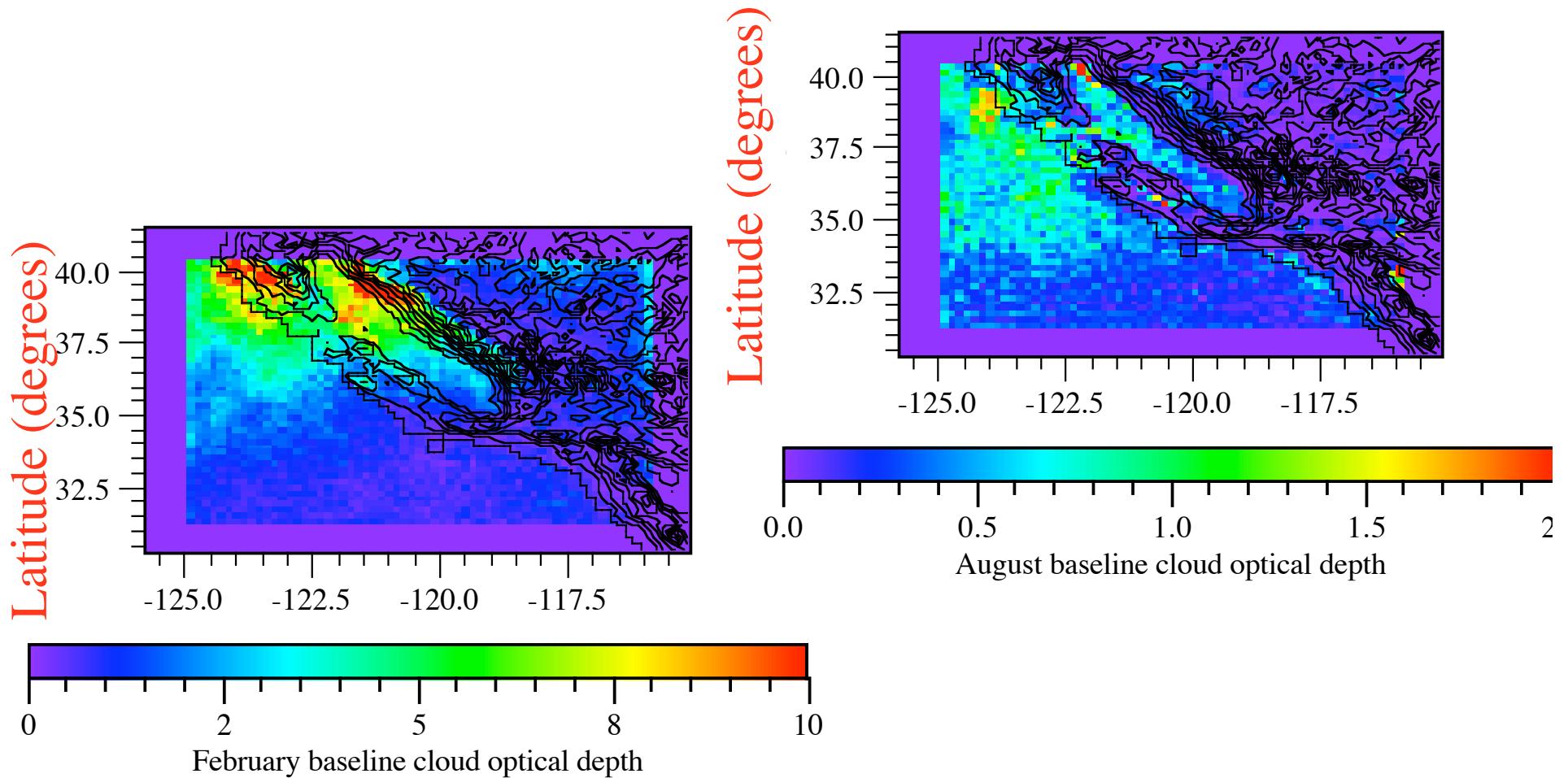
## Surface processes

Soil, water, snow, sea ice, vegetation,  
road, roof temperatures/moisture  
Ocean 2-D dynam., 3-D diffus/chem.  
Ocean-atmosphere exchange

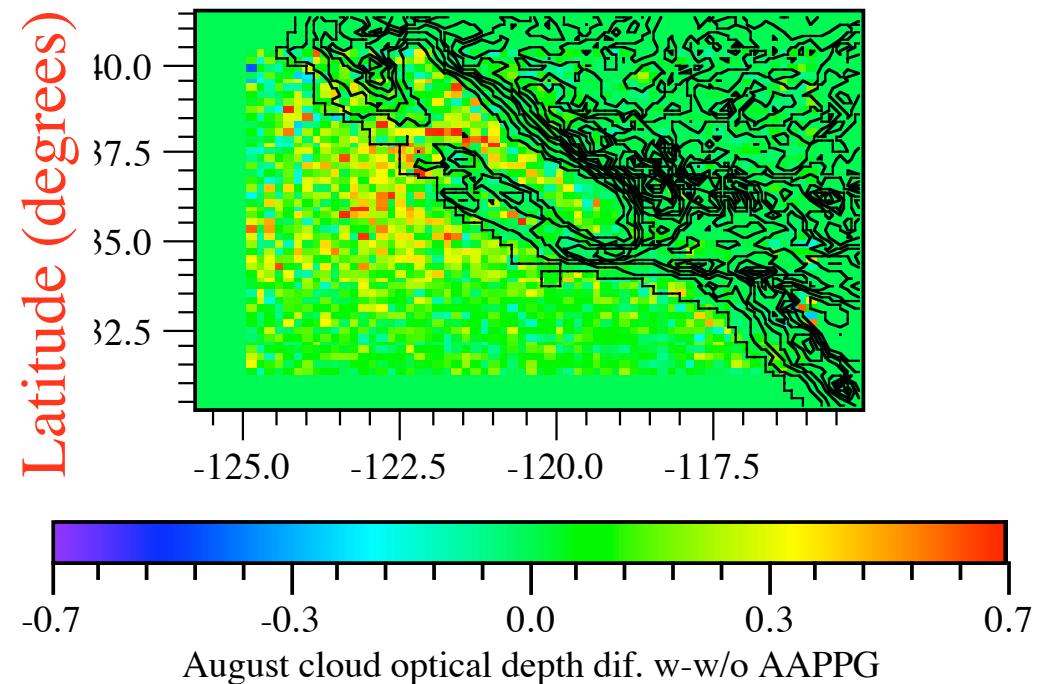
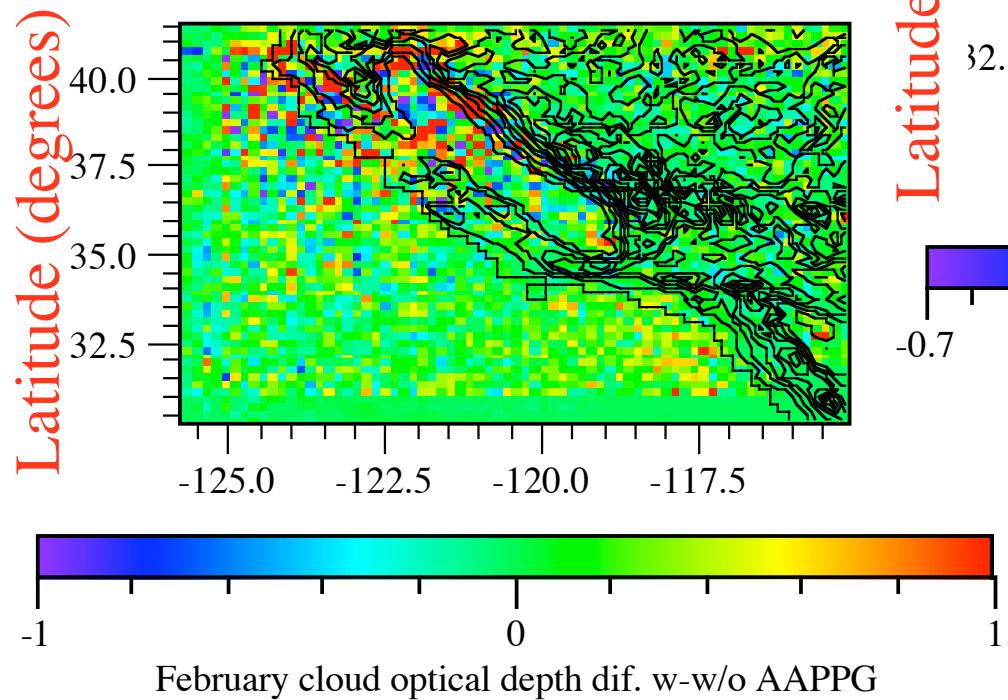
# Feb/Aug Aerosol 550 nm Optical Depth Dif. w-w/o AAPPG



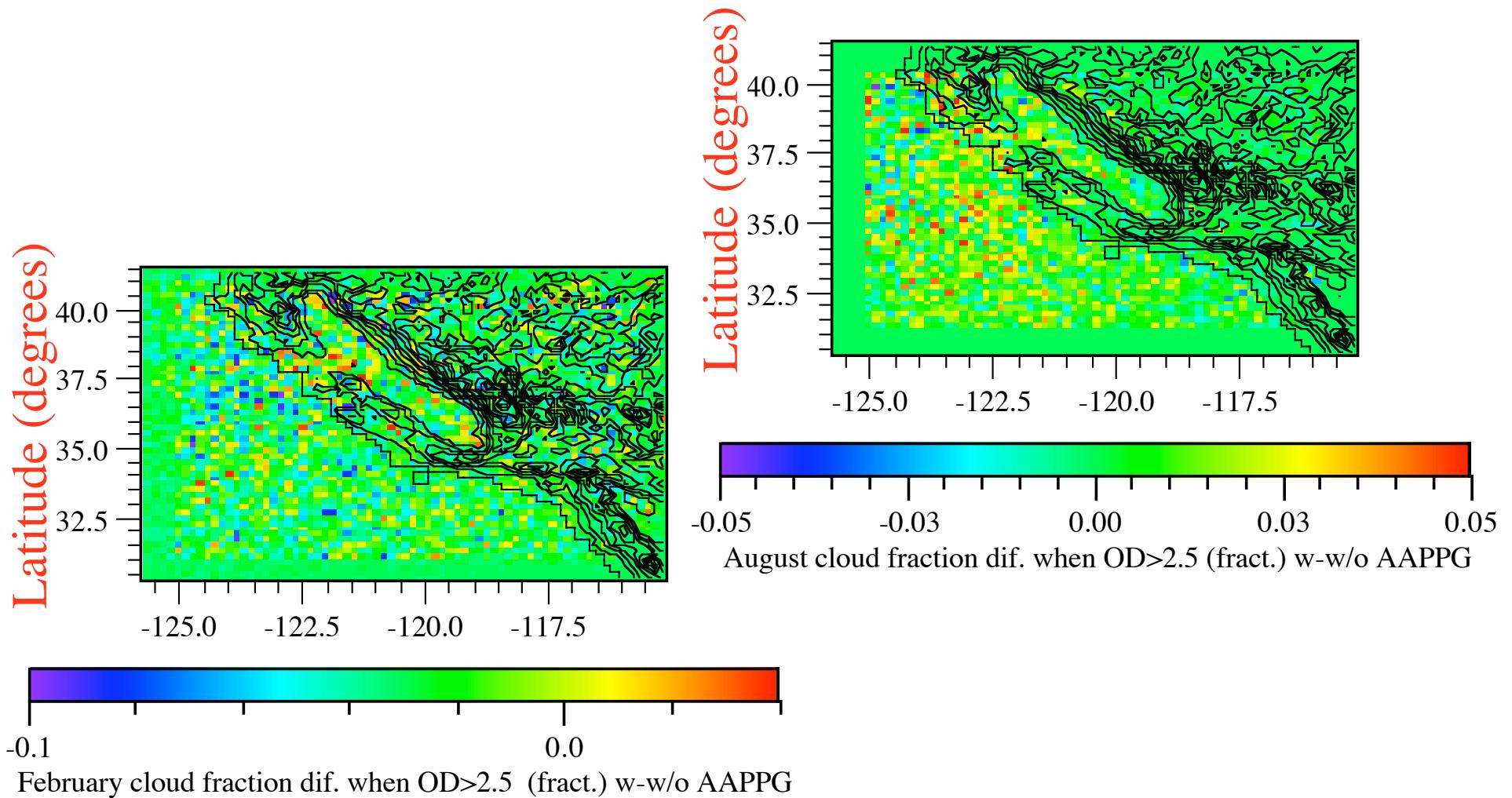
# Feb/Aug Baseline Cloud Opt. Depth



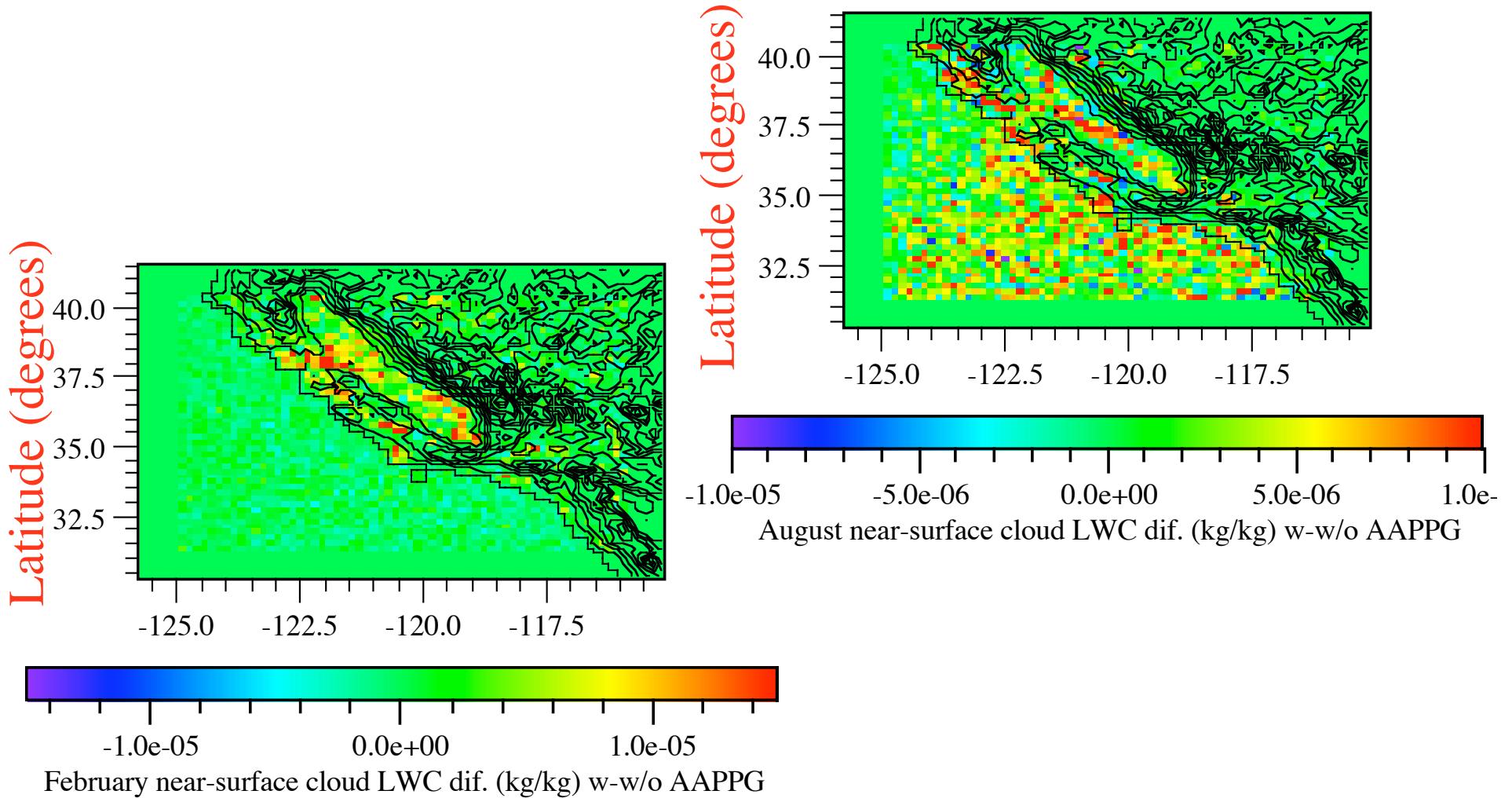
# Feb/Aug Cloud Optical Depth Dif. w- w/o AAPPG



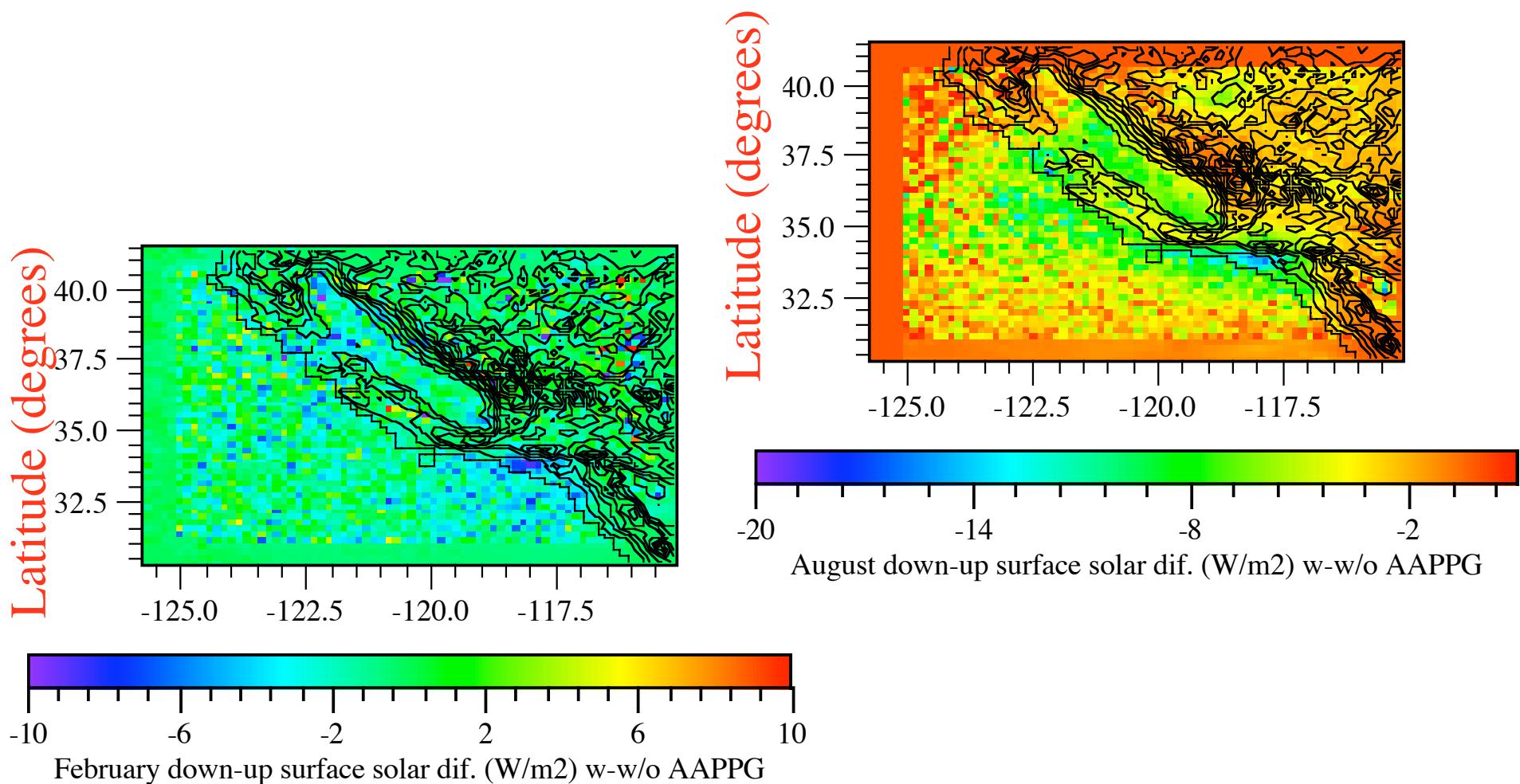
# Feb/Aug Near-Surface Cloud Fraction Dif. w-w/o AAPPG



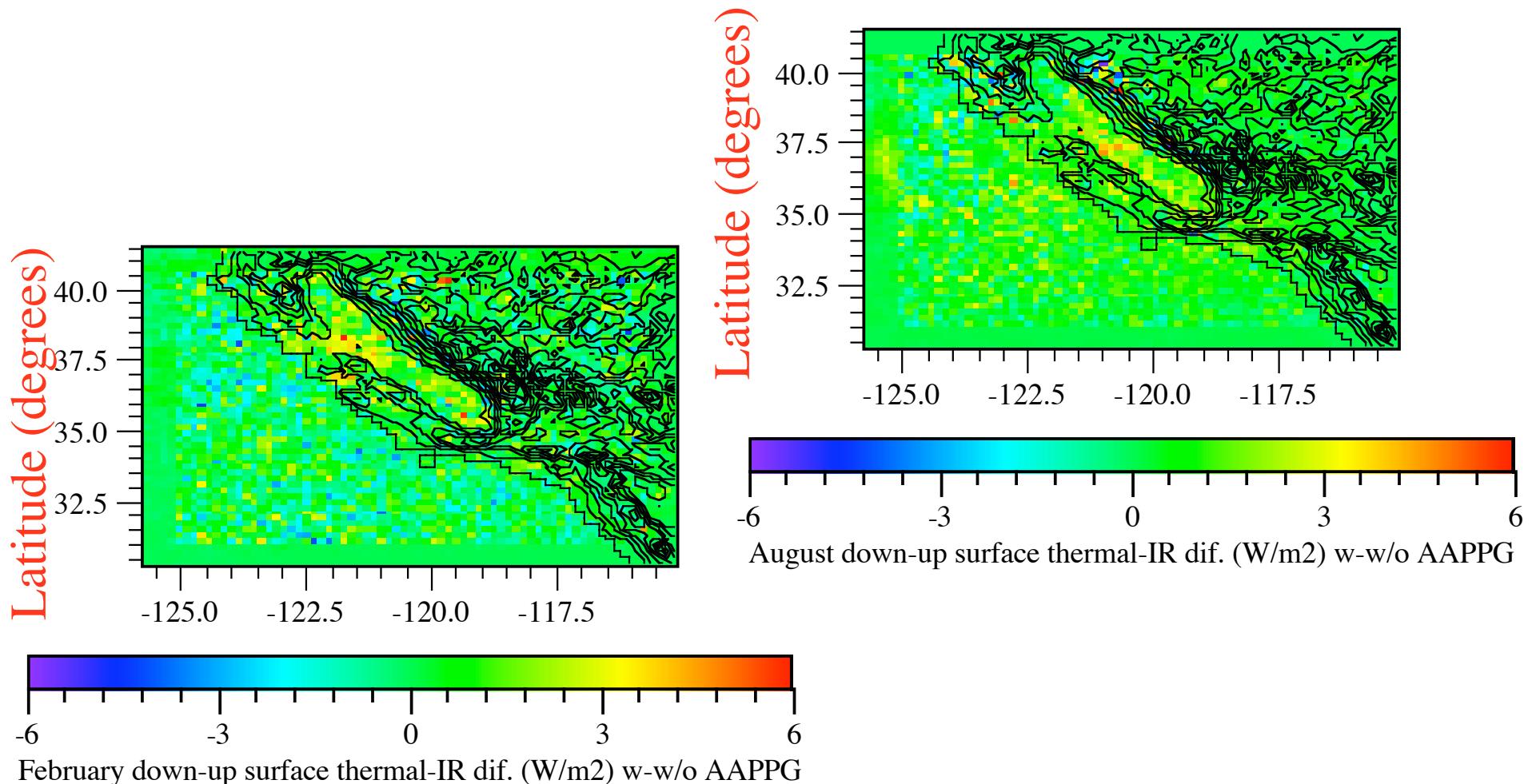
# Feb/Aug Cloud LWC Dif. w-w/o AAPPG



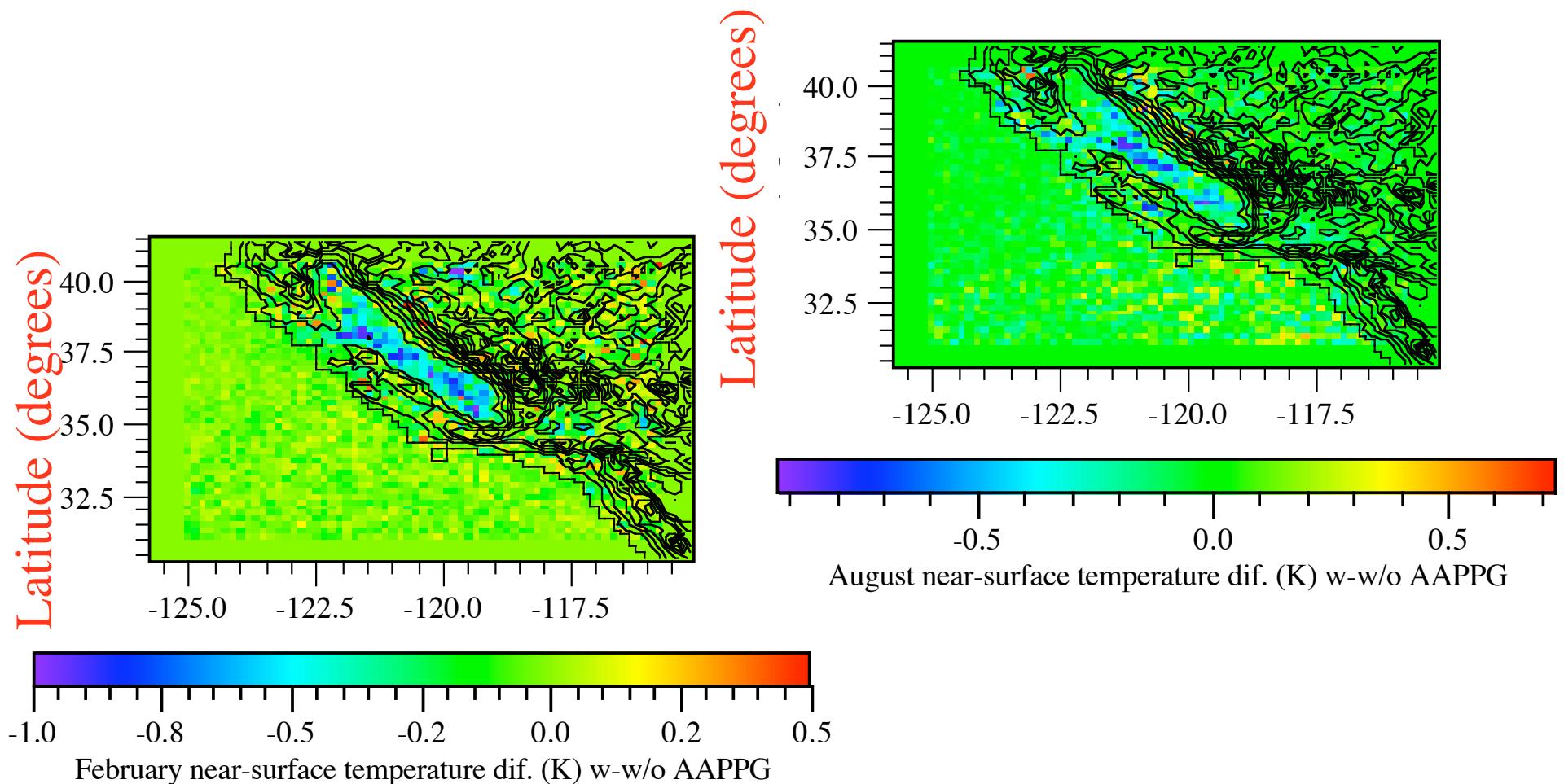
# Feb/Aug Down-Up Surface Solar Radiation Dif. w-w/o AAPPG



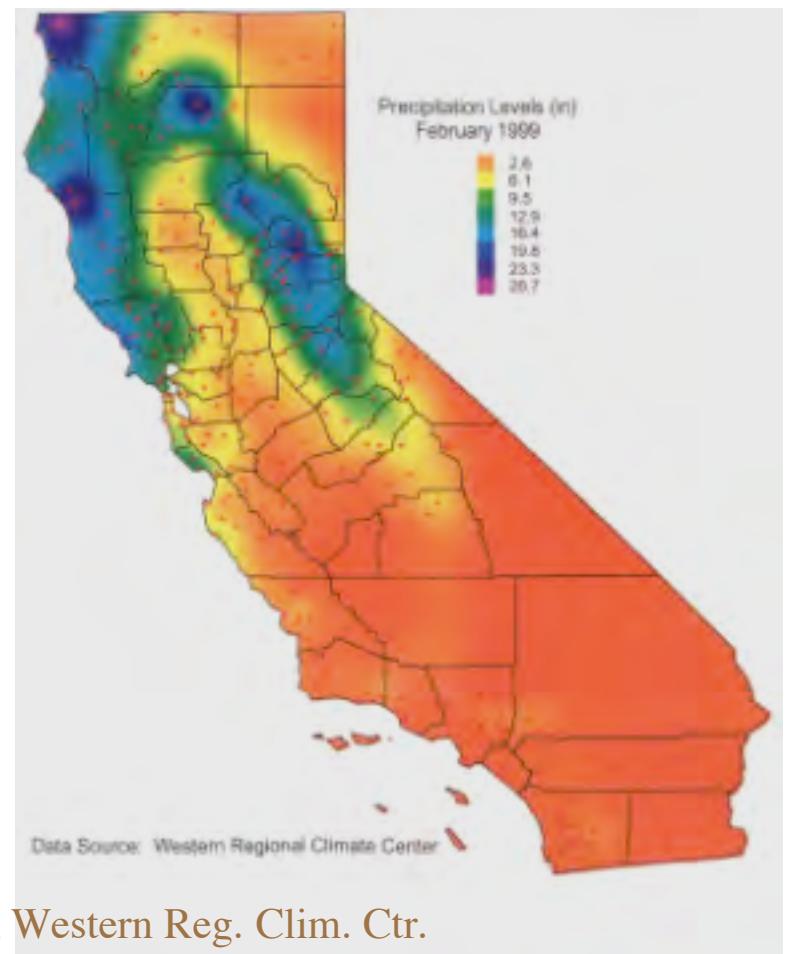
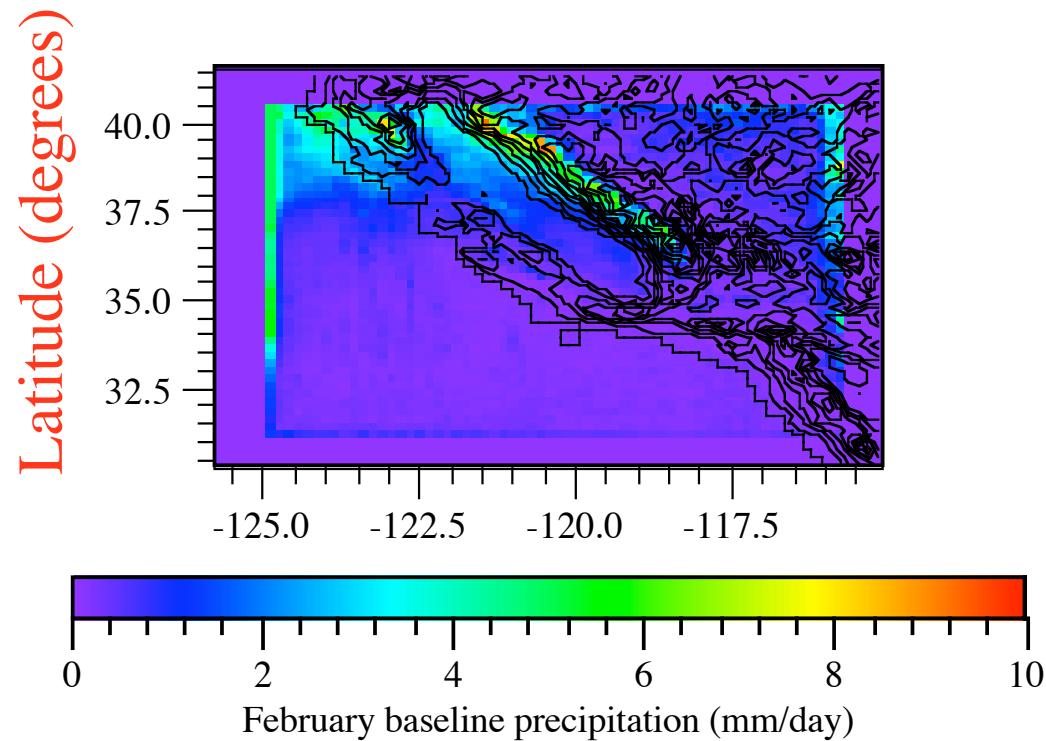
# Feb/Aug Down-Up Surface Thermal-IR Radiation Dif. w-w/o AAPPG



# Feb/Aug Near-surface Temperature Dif. w-w/o AAPPG

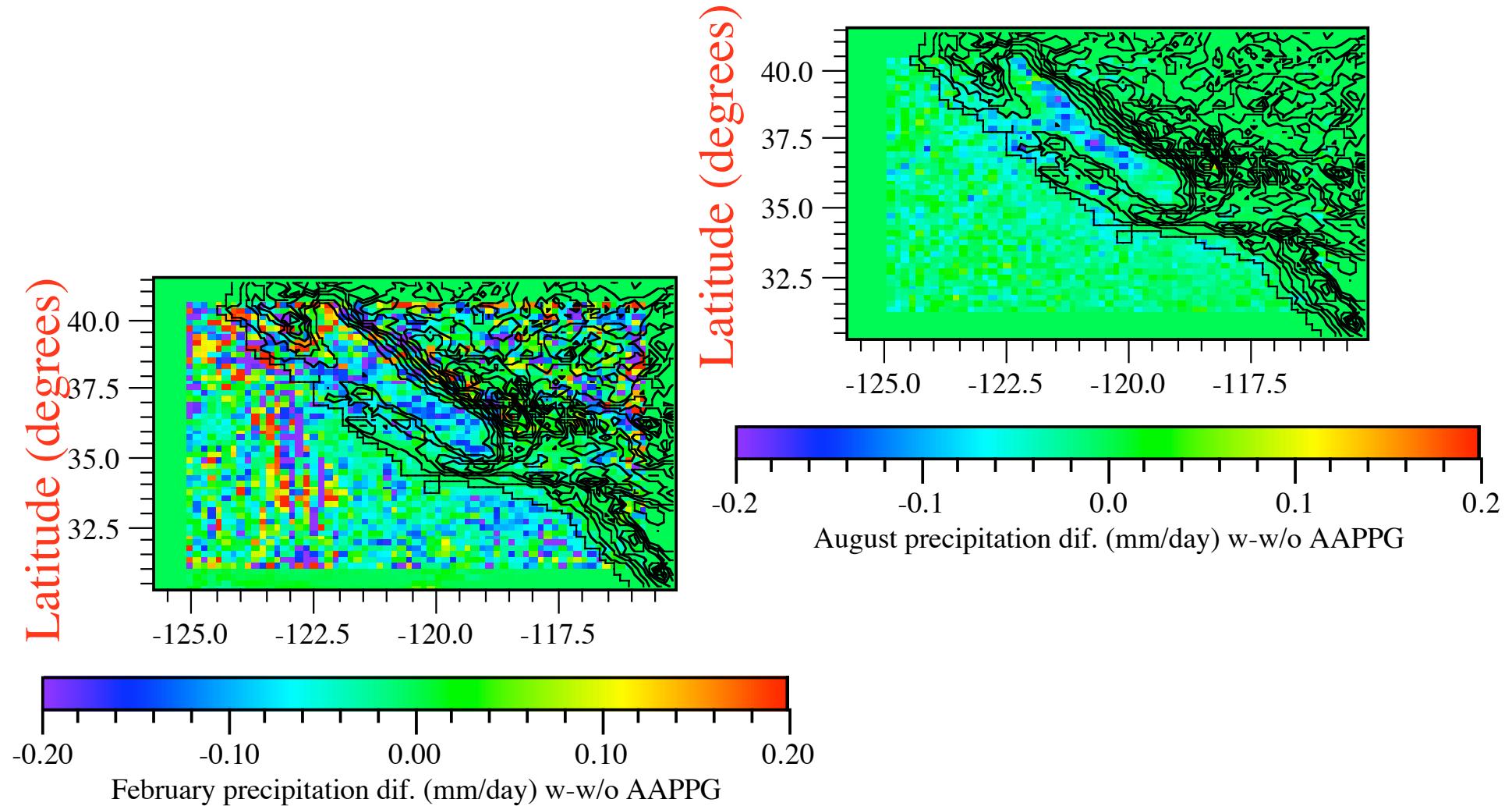


# Modeled vs. Measured Feb. 1999 Precipitation

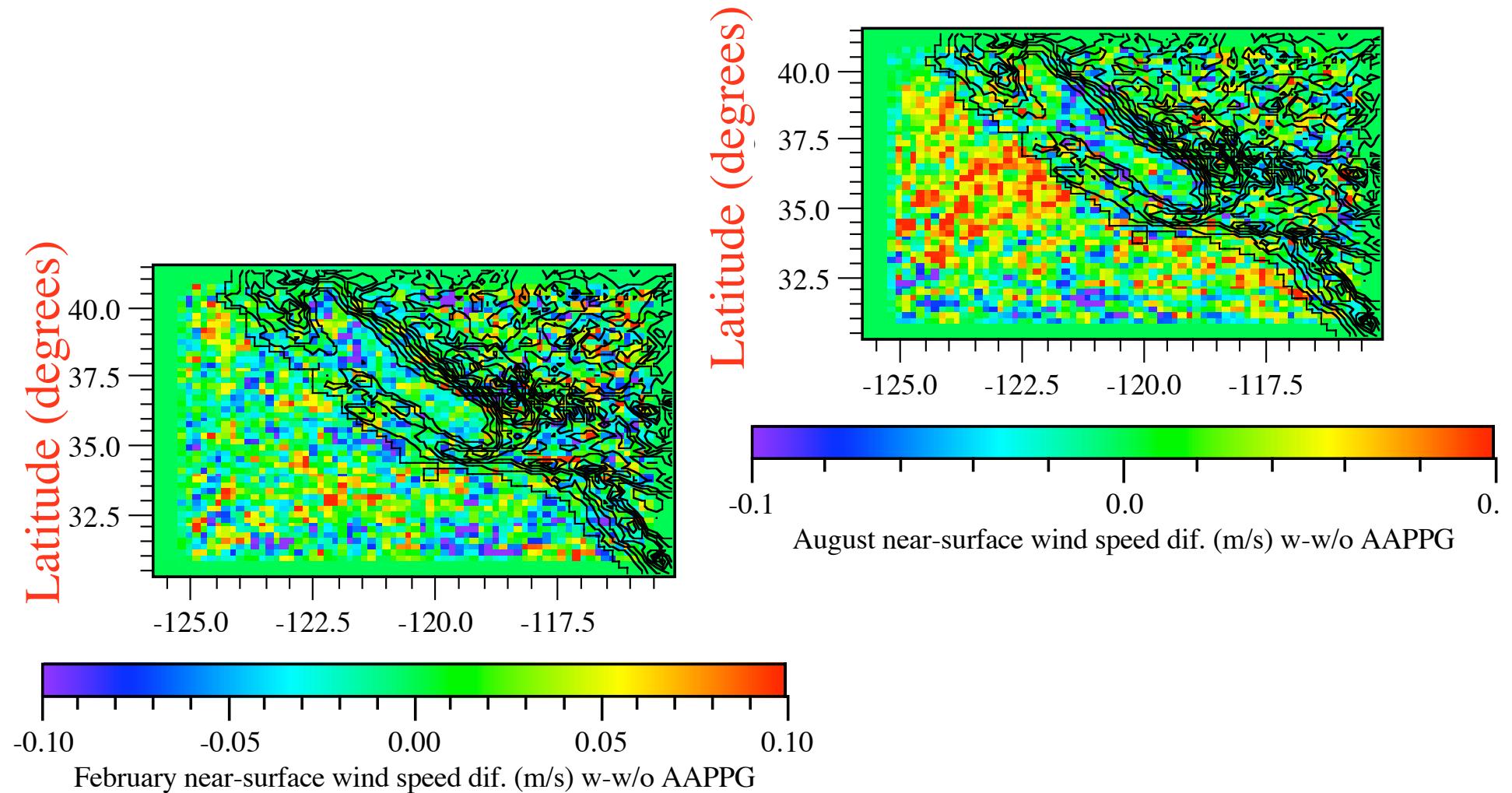


Data from Western Reg. Clim. Ctr.  
Prepared by G. Lopez, G. Franco,

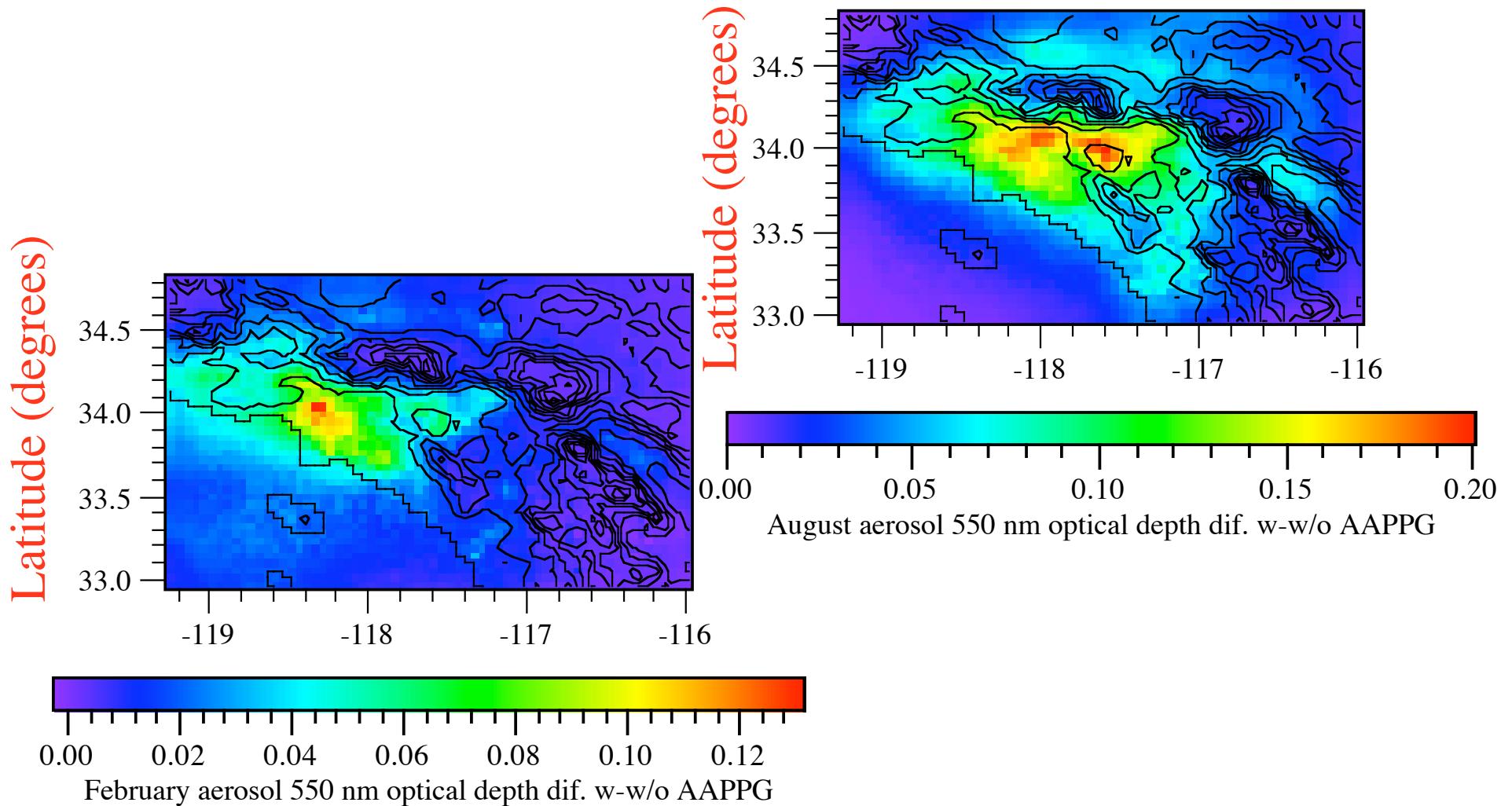
# Feb/Aug Precipitation Dif. w-w/o AAPPG



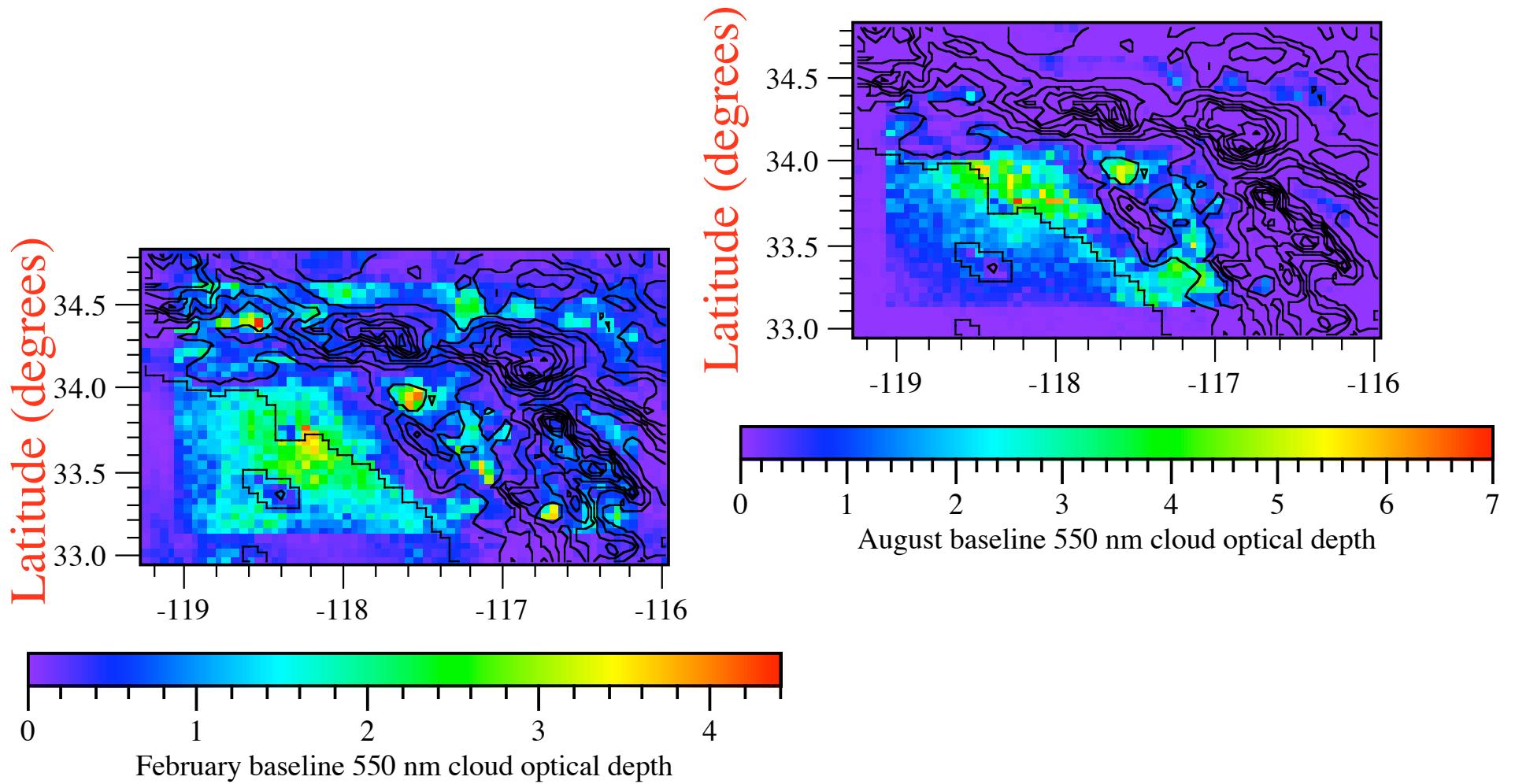
# Feb/Aug Near-Surface Wind Speed Dif. w-w/o AAPPG



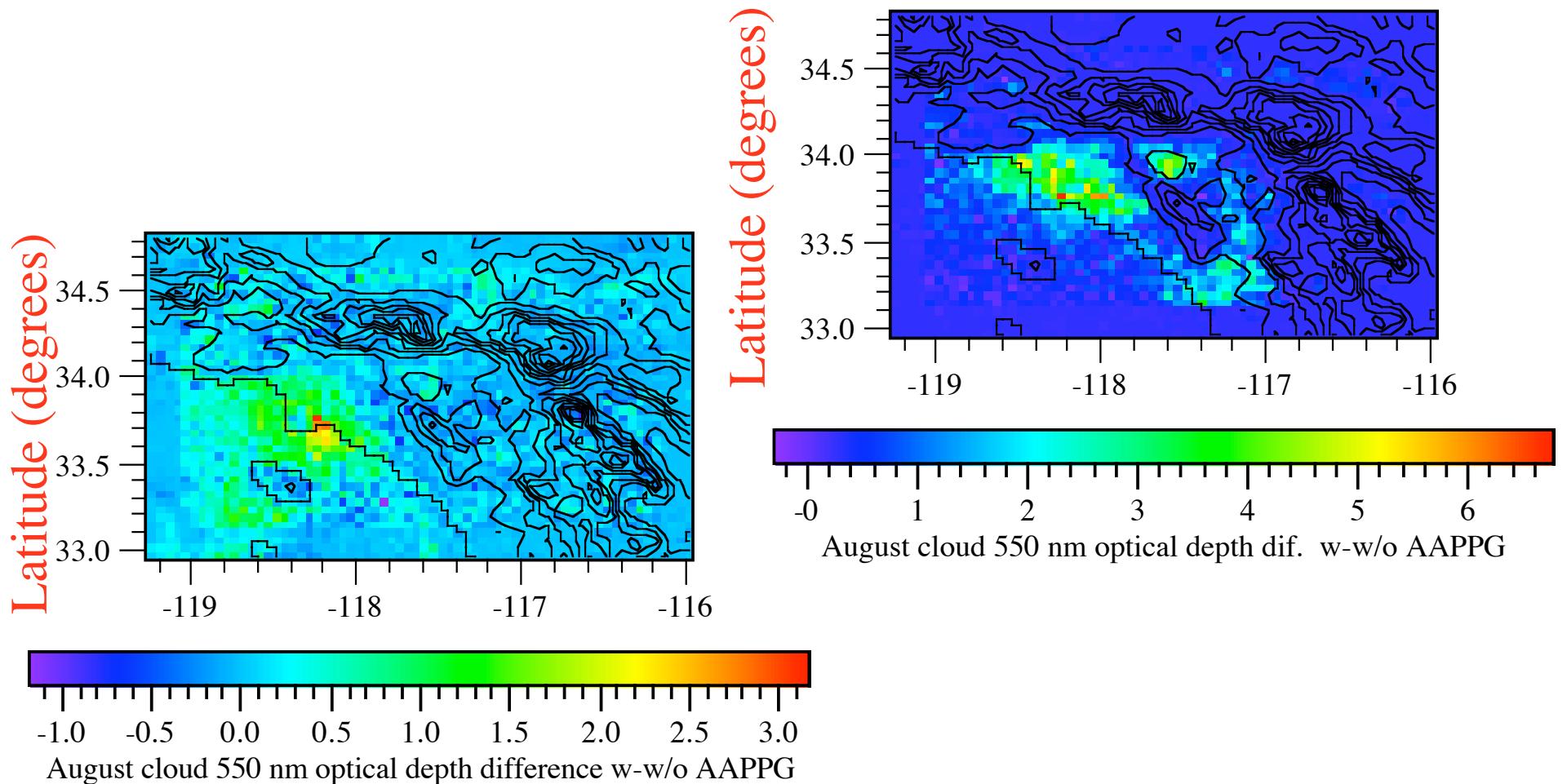
# Feb/Aug Aerosol 550 nm Optical Depth Dif. w-w/o AAPPG



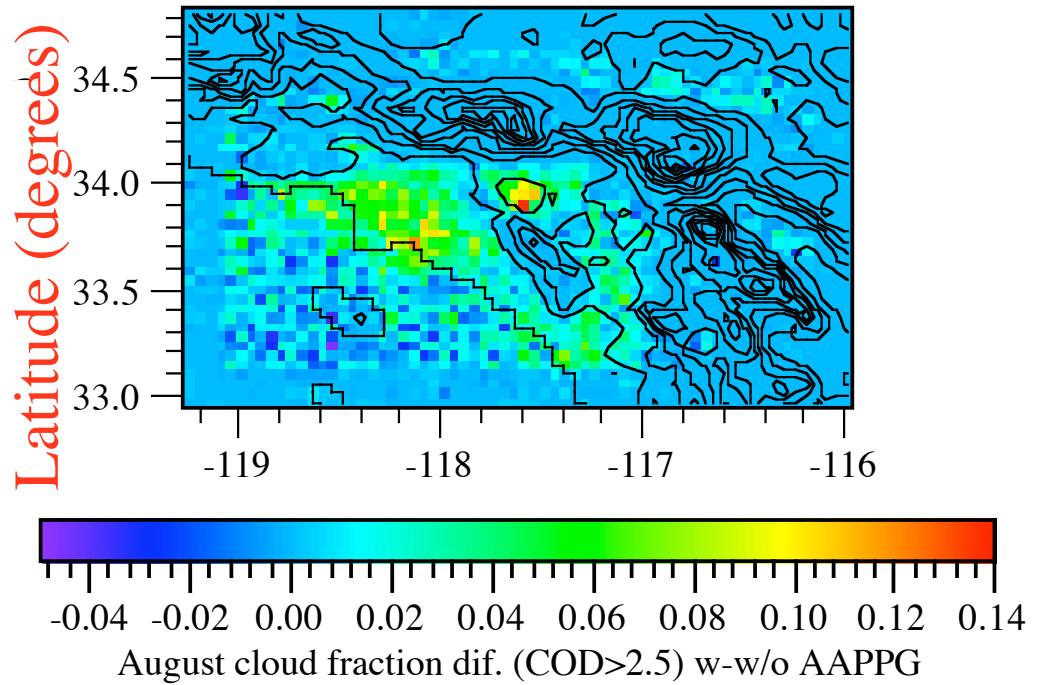
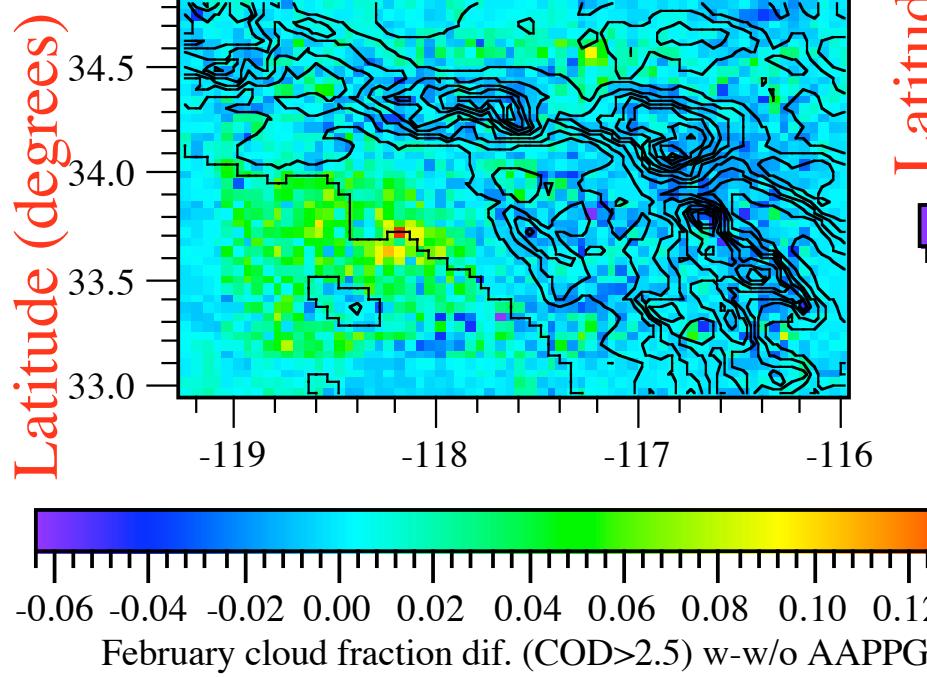
# Feb/Aug Baseline Cloud Opt. Depth



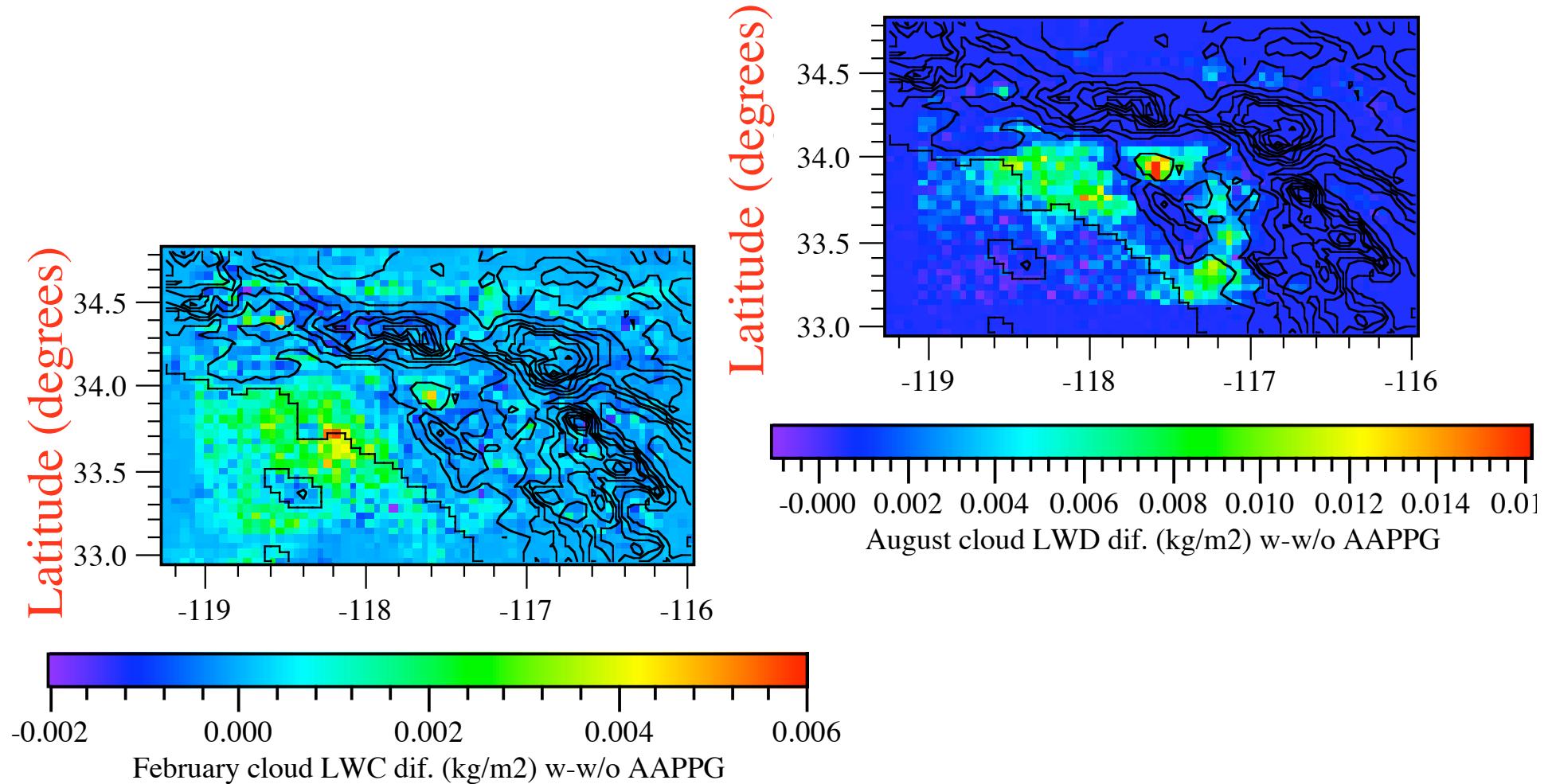
# Feb/Aug Cloud Optical Depth Dif. w-w/o AAPPG



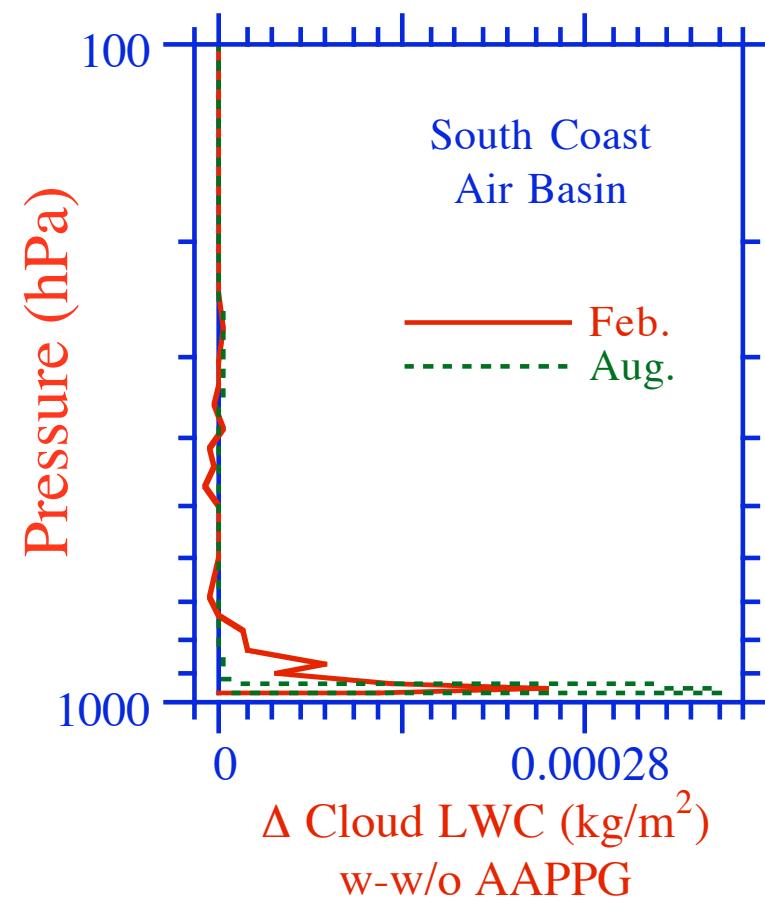
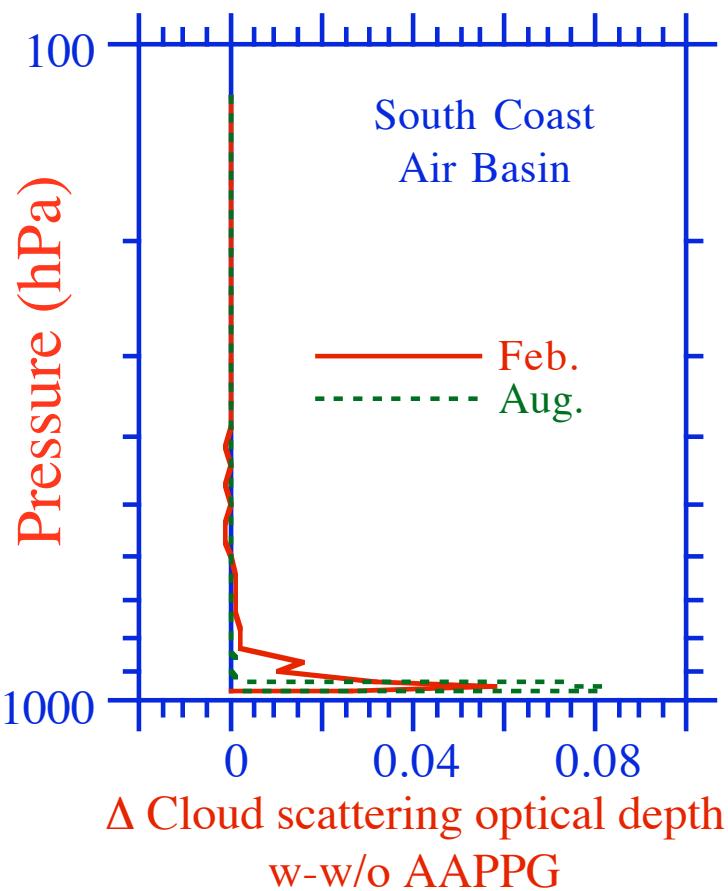
# Feb/Aug Near-Surface Cloud Fraction Dif. w-w/o AAPPG



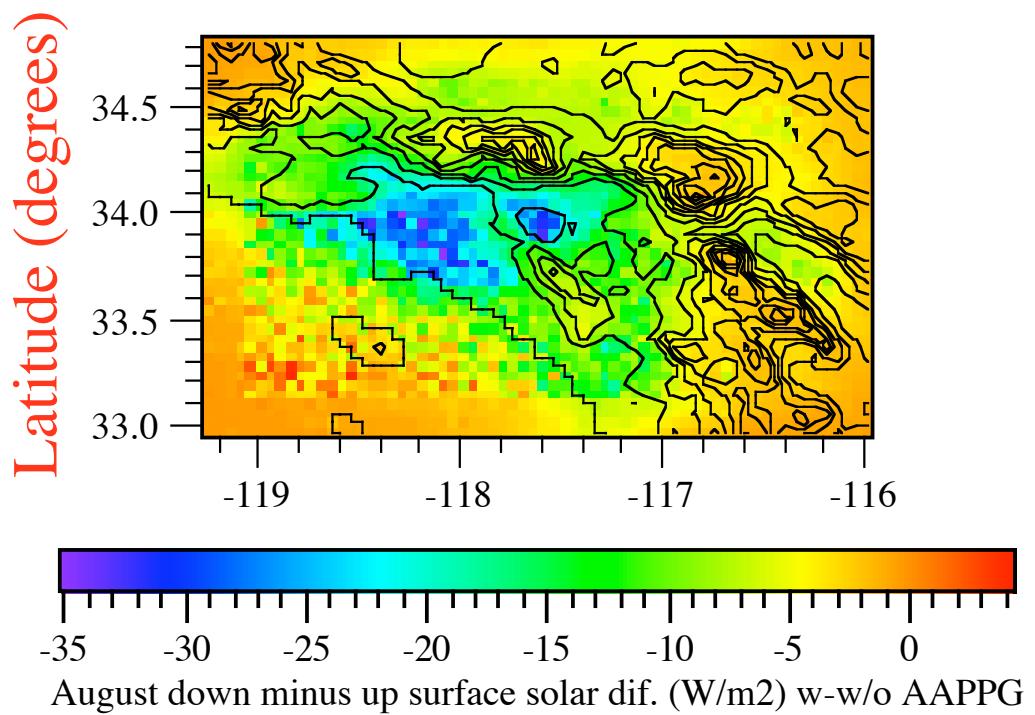
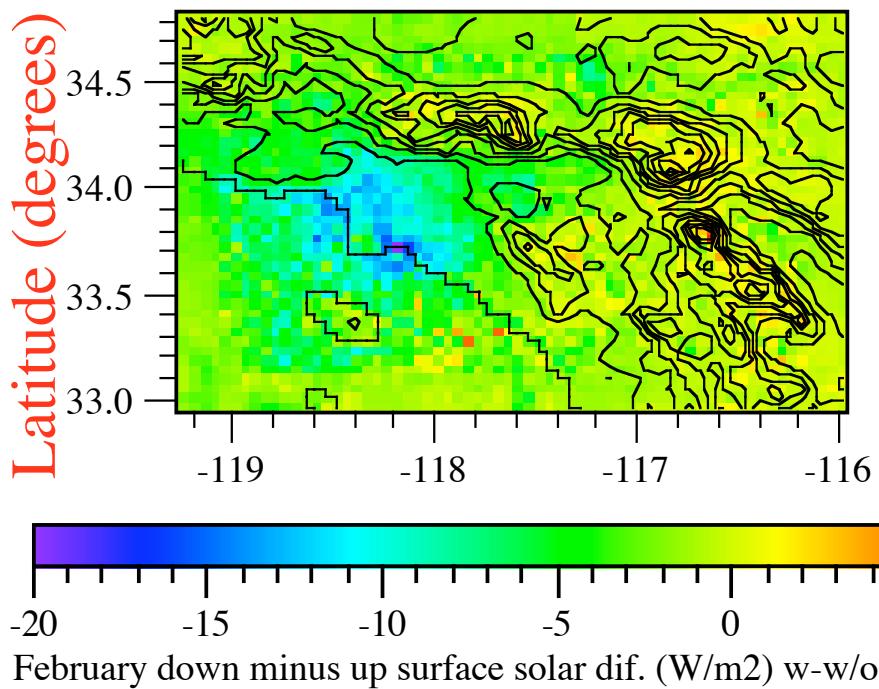
# Feb/Aug Cloud LWC Dif. w-w/o AAPPG



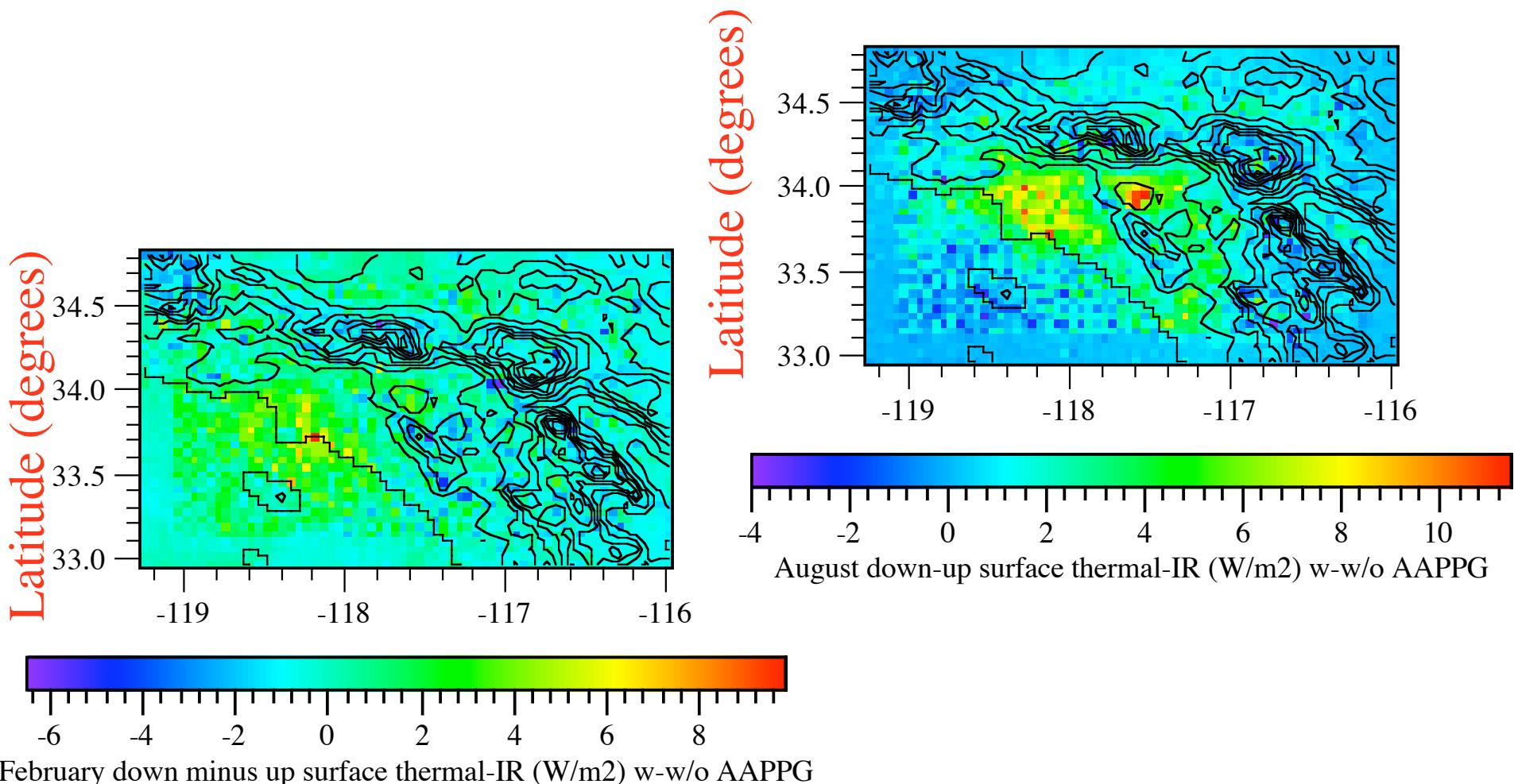
# South-Coast Averaged Cloud Scattering, LWC Dif. w-w/o AAPPG



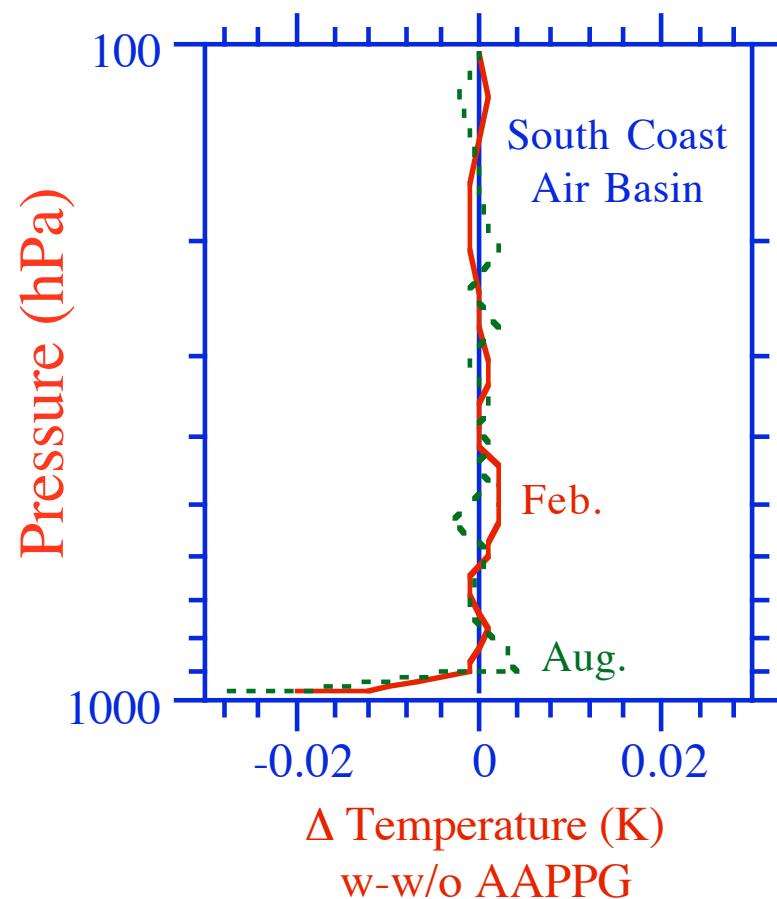
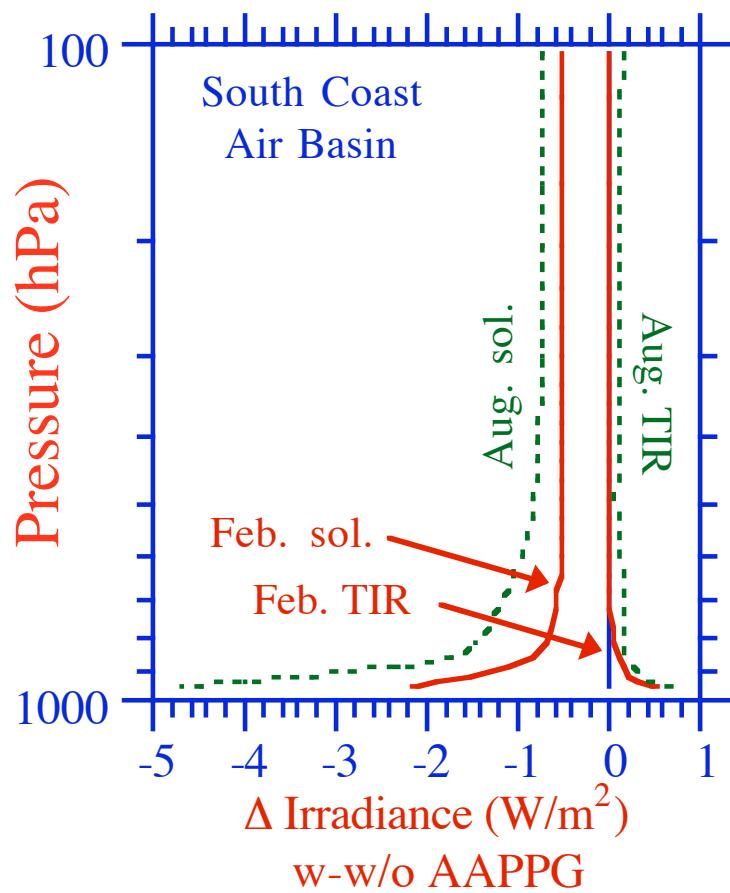
# Feb/Aug Down-Up Surface Solar Radiation Dif. w-w/o AAPPG



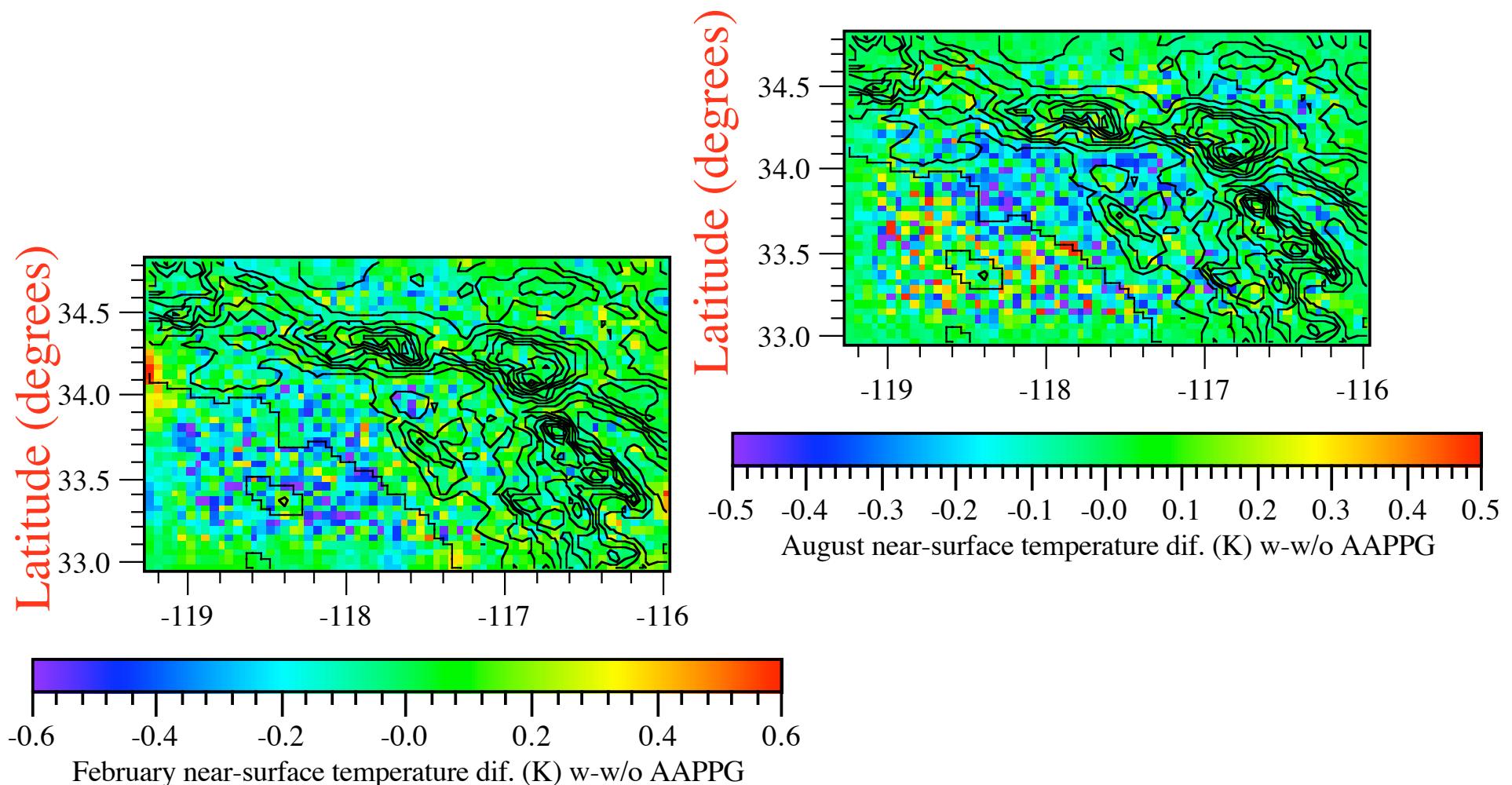
# Feb/Aug Down-Up Surface Thermal-IR Radiation Dif. w-w/o AAPPG



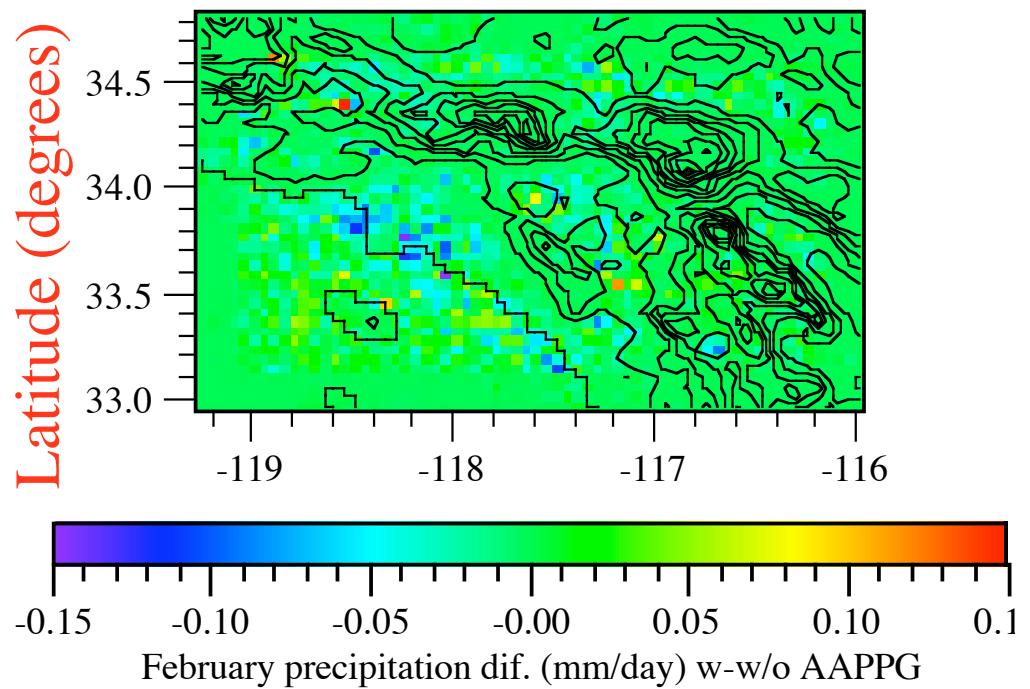
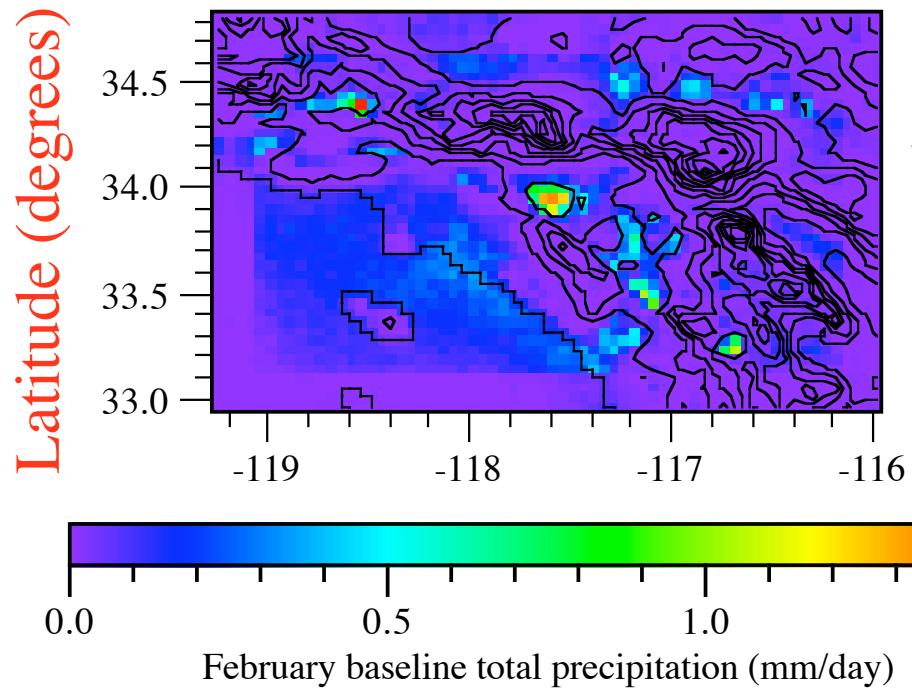
# South-Coast Averaged Irradiance (Sol, IR) and Temperature Dif. w-w/o AAPPG



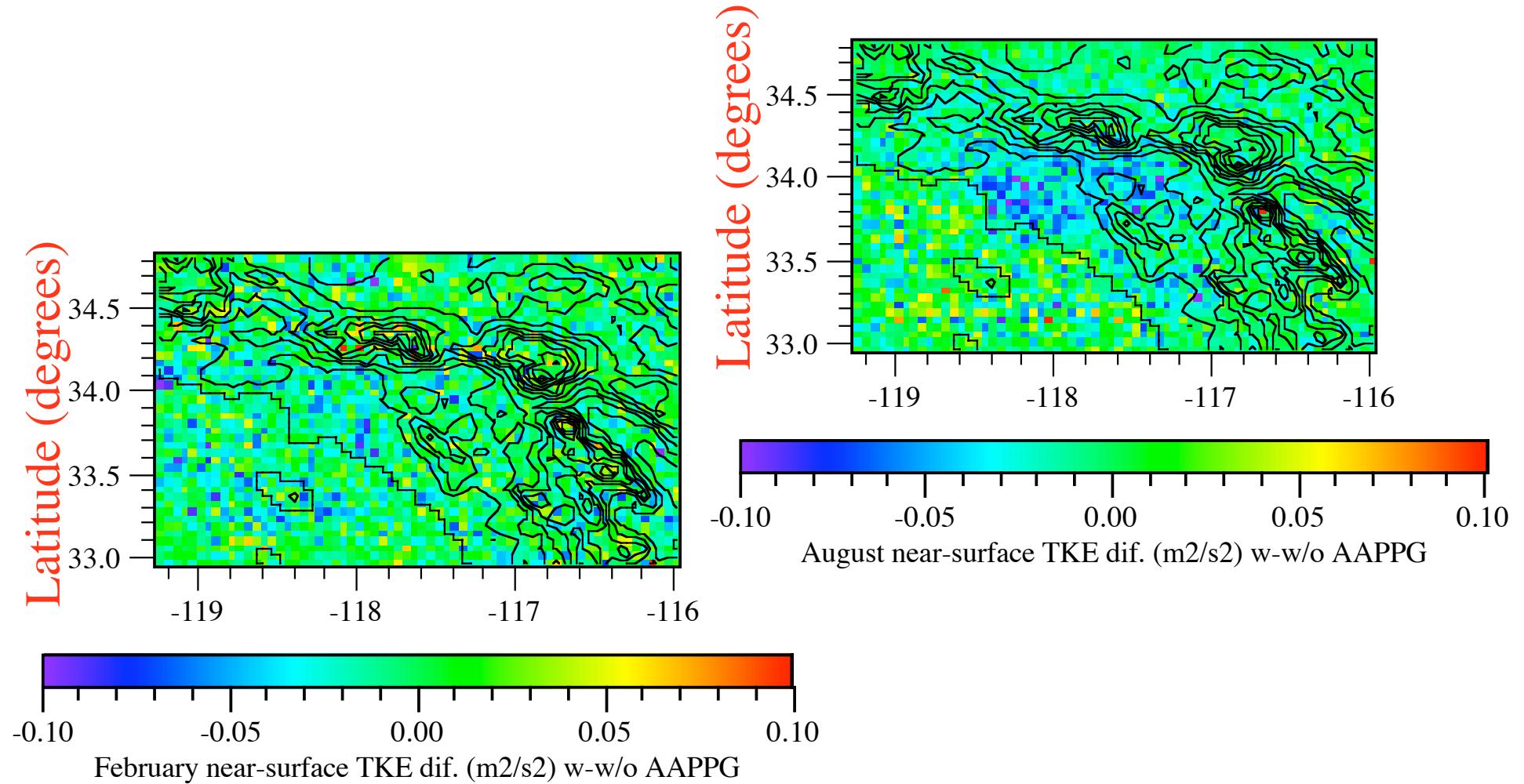
# Feb/Aug Near-surface Temperature Dif. w-w/o AAPPG



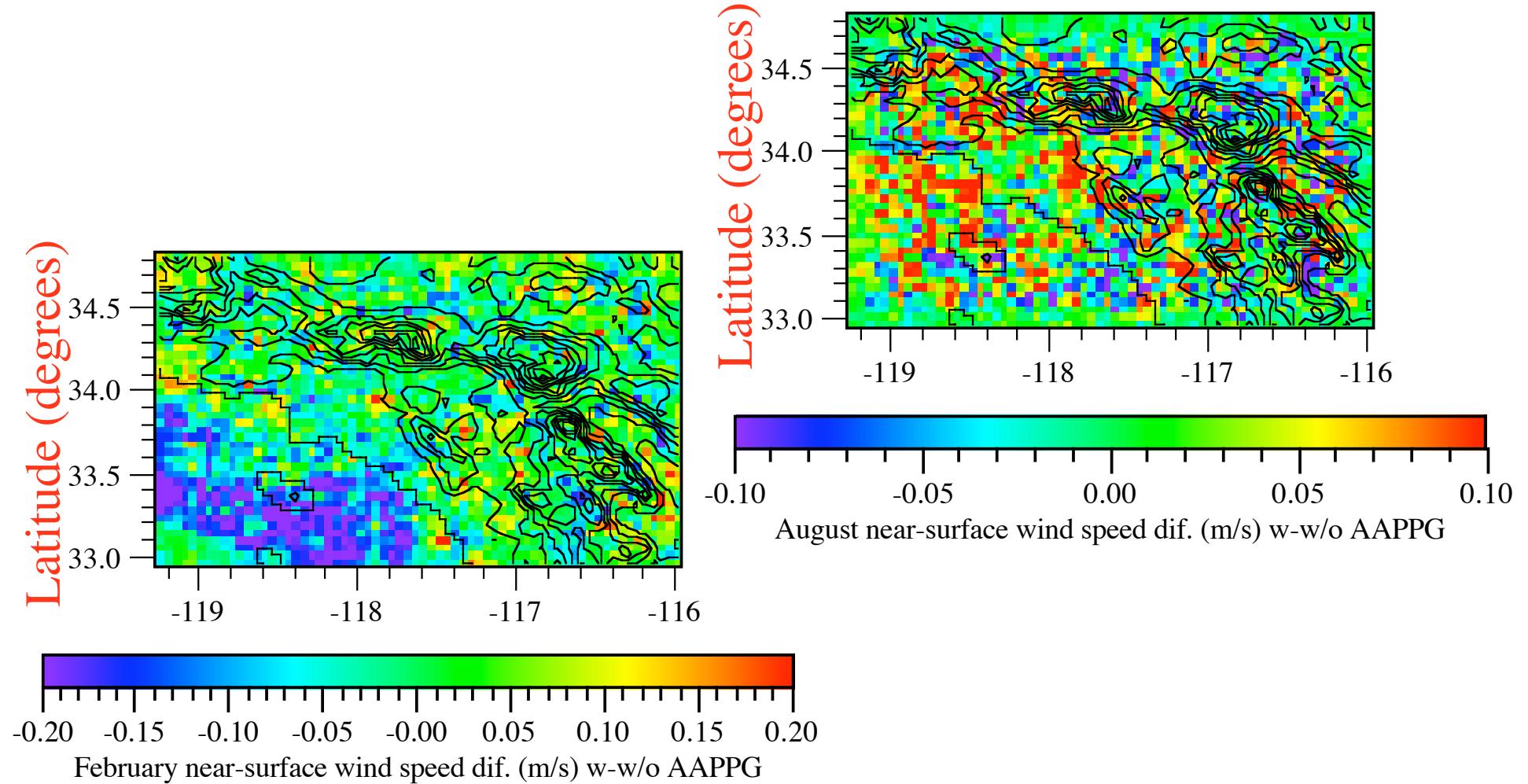
# Feb. Baseline and Diff. In Precip.



# Feb/Aug Near-Surface TKE Dif. w-w/o AAPPG



# Feb/Aug Near-Surface Wind Speed Dif. w-w/o AAPPG



# Implications for Rainfall

Rainfall in California: 193 million acre-feet/year (1.54 mm/day)

Flow to reservoirs (agriculture/cities/industry): 12.9% (24.9 maf/yr)

Precipitation reduction due to APPG: 6.5% (12.5 maf/yr)

Runoff loss to reservoirs: 1.6 maf/yr

Estimate of California population by 2010: 40 million

Estimate of additional water needed by 2010: 4-6 maf/yr

# Implications for Wind Energy

Annual energy output from wind turbine (kWh/yr)

$$E = P \times 8760 \times CF$$

P = Turbine rated power (kW)

CF = Capacity Factor ( $0.087V^3/P/D^2$ ) (*Science*, 293, 1438, 2001)

V = Mean-annual Rayleigh-distributed wind speed (m/s)

D = Blade diameter (m)

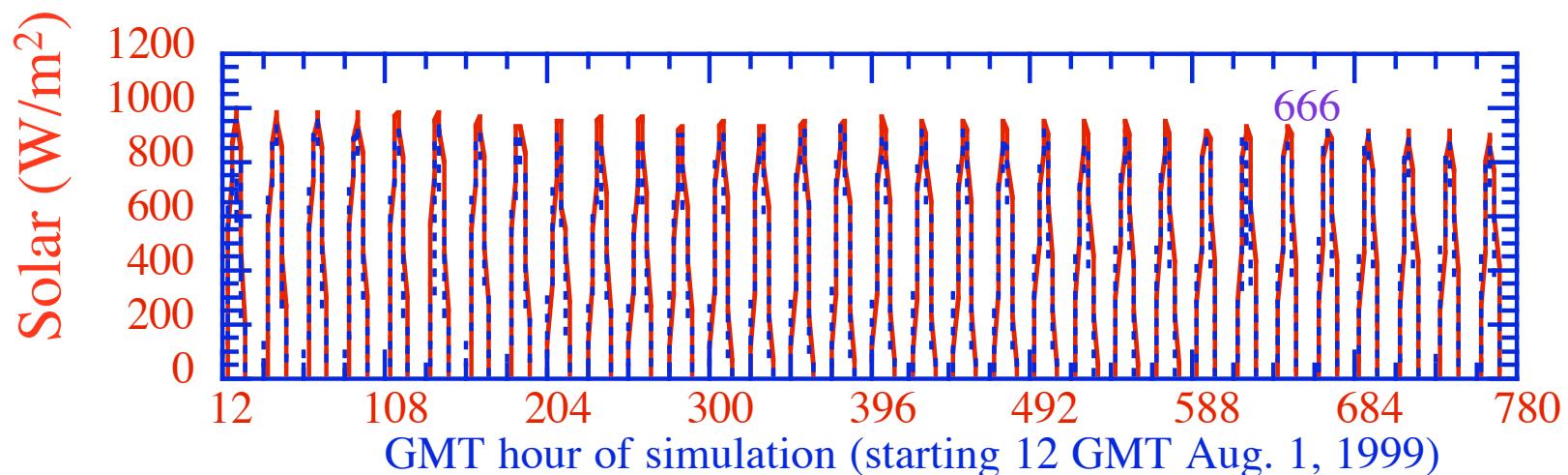
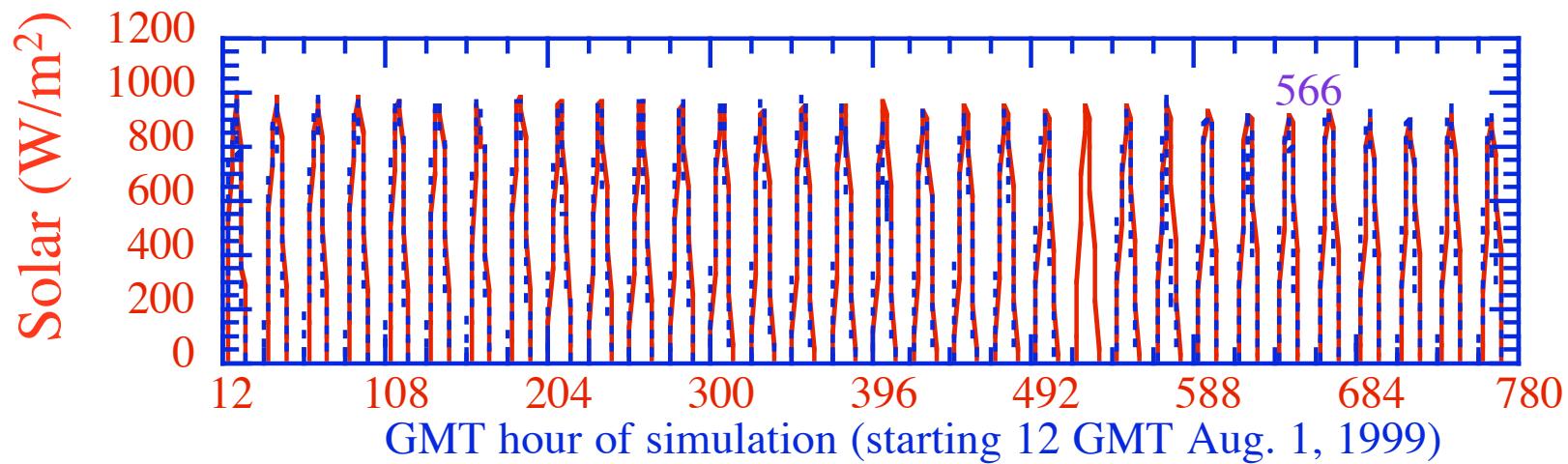
1500 kW turbine, 77-m diameter blade,

V=6.4 m/s without AAPPG

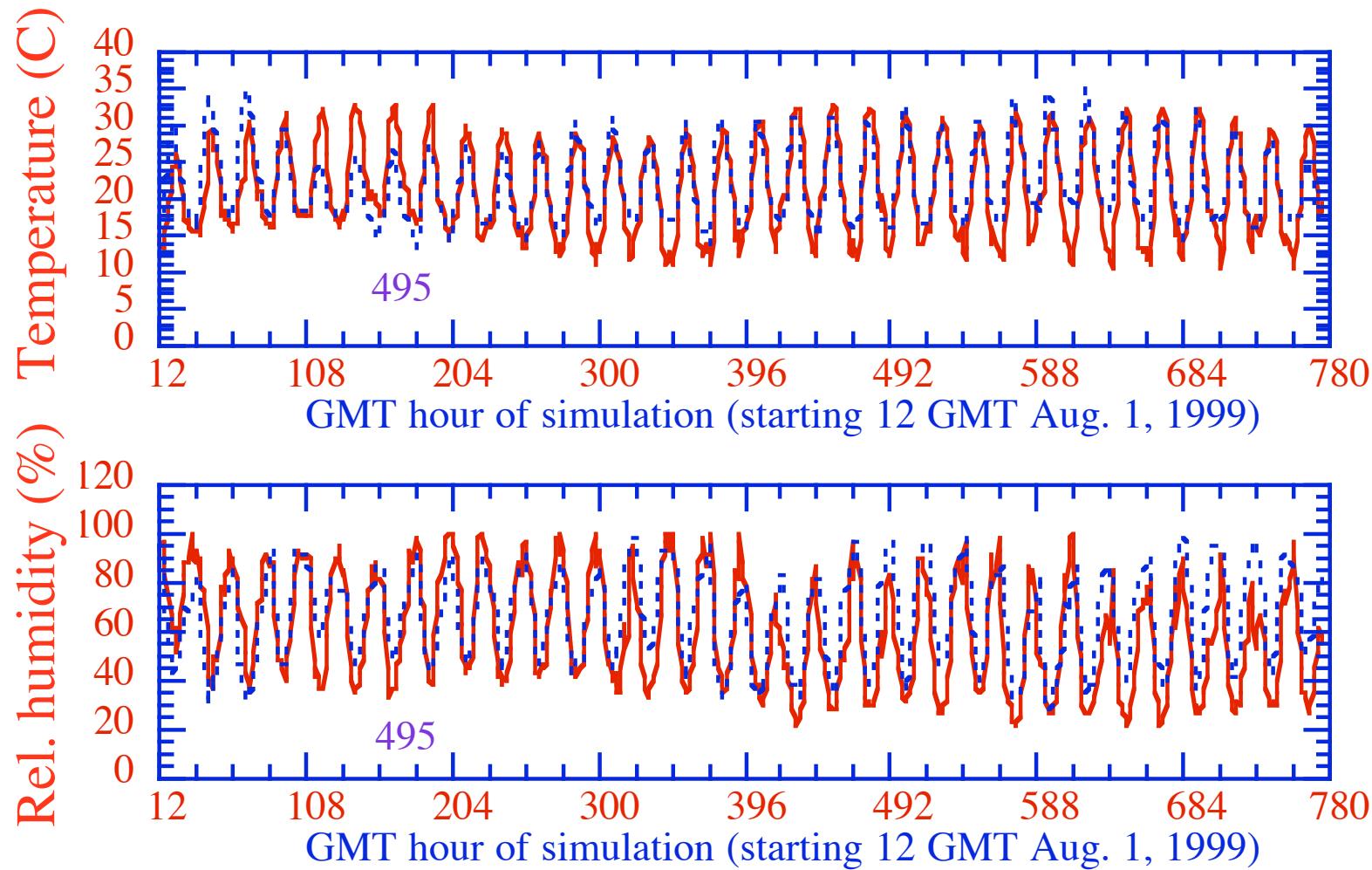
V=6.32 m/s with AAPPG

Energy loss with AAPPG 2.3 % (wind loss was 1.25%)

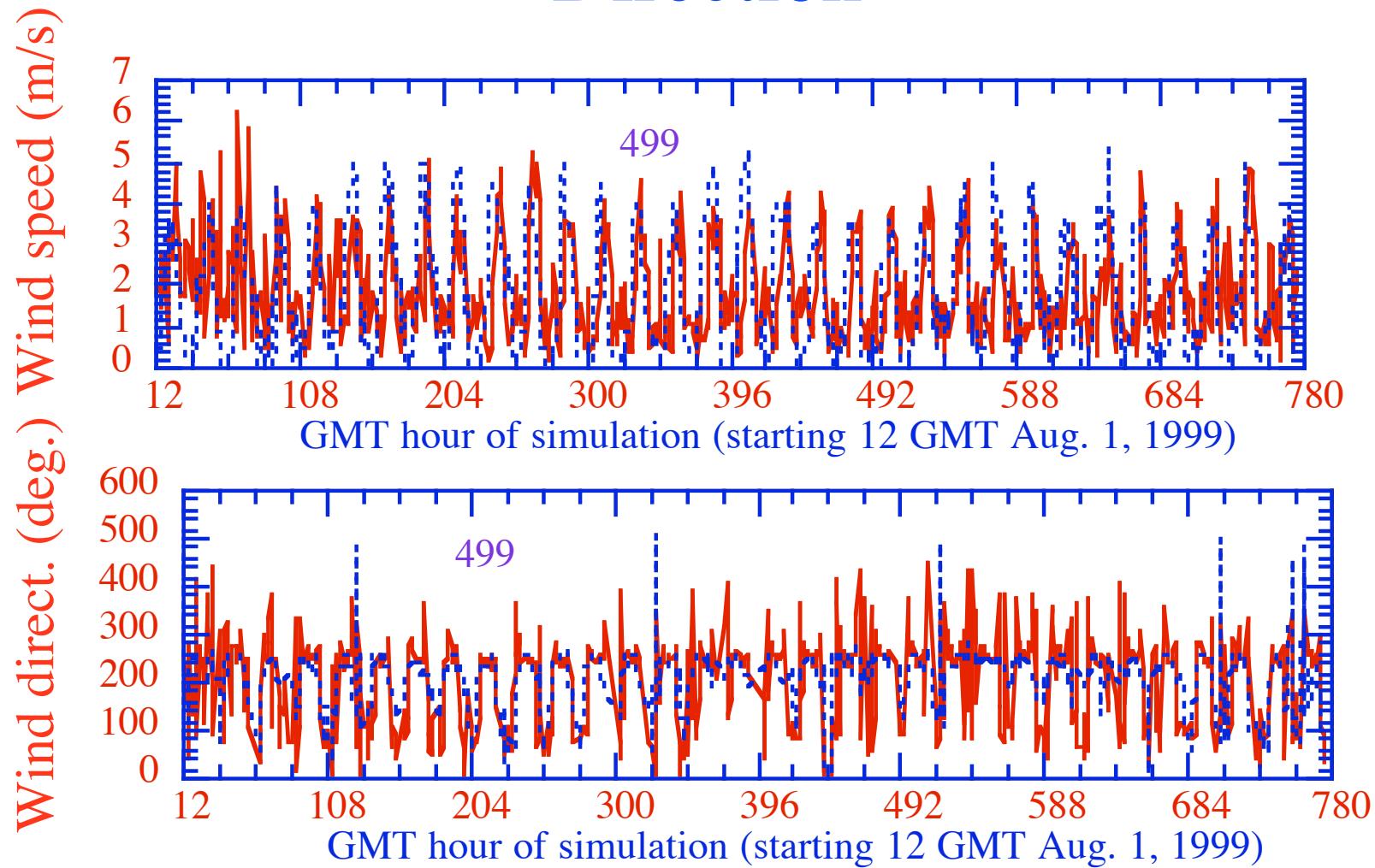
# Paired-in-Time-and-Space Modeled (Red) v. Measured Solar Radiation



# Paired-in-Time-and-Space Modeled (Red) v. Measured T and RH



# Paired-in-Time-and-Space Modeled (Red) v. Measured Wind Speed & Direction



# Summary

Anthropogenic aerosols and gas precursors in California and South Coast were found to

- decrease near-surface wind speeds
- decrease rainfall in the Central Valley, South Coast
- increase cloud optical depth, fraction, LWC
- decrease near-surface air temperatures
- stabilize the boundary layer
- decrease solar radiation at surface
- increase thermal-IR radiation at surface